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THE EXPERIMENTAL ANALYSIS OF VOCATIONAL BEHAVIOR IN SEVERELY RETARDED MALES.

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WORKING FROM A POPULATION OF SEVERELY AND PROFOUNDLY RETARDED RESIDENTIAL SCHOOL PATIENTS, AN ATTEMPT WAS MADE TO DEVISE AN EXPERIMENTAL PROGRAM FOR TRAINING SUBJECTS ON SELECTED WORKSHOP TASKS. TASK ANALYSIS WAS EMPLOYED TO DESCRIBE THE RESPECTIVE VOCATIONAL ENVIRONMENTS AND TO SPECIFY BEHAVIORAL REQUIREMENTS. TRAINING PROGRAMS BASED UPON THE SKINNERIAN PRINCIPLES OF SHAPING, OPERANT DISCRIMINATION, AND CHAINING OF RESPONSES WERE THEN DEVELOPED AROUND THE RESULTS OF THE TASK ANALYSIS. A PRELIMINARY STUDY WAS CONDUCTED TO DETERMINE THE RESPONSE ACQUISITION CHARACTERISTICS OF A RANDOM SAMPLE OF 10 SUBJECTS. THE DATA SUGGEST THAT THE ACQUISITION OF COMPLEX CHAINS OF OVER 100 DISCRETE BEHAVIORS IS REFLECTED IN POSITIVELY ACCELERATED EXPONENTIAL CURVES AND ARE, IN GENERAL, CONSISTENT WITH BEHAVIORAL PREDICTIONS DERIVED THROUGH THE AFOREMENTIONED PRINCIPLES. A SECOND STUDY WAS CONDUCTED TO TEST THE EFFECTS OF TWO REINFORCEMENT PROCEDURES ON THE MAINTENANCE OF THE ACQUIRED CHAINS, EMPLOYING TWO GROUPS OF 11 RANDOMLY SELECTED SUBJECTS. THE CONTROL GROUP WAS EXPOSED TO RELATIVELY LOW BUT CONSTANT LEVELS OF SOCIAL REINFORCEMENT. THE EXPERIMENTAL GROUP RECEIVED EXTRINSIC (TOKEN) REINFORCERS DELIVERED IN ACCORDANCE WITH PRESCRIBED SCHEDULES. THE RESULTS SUGGEST THAT SCHEDULES EXTRINSIC REINFORCEMENT MAINTAINED HIGHER AND MORE STABLE RATES OF VOCATIONAL BEHAVIOR THAN ESSENTIALLY NON-CONTINGENT SOCIAL REINFORCEMENT. A BIBLIOGRAPHY LISTS 52 REFERENCES. TABLES, FIGURES, AND APPENDIXES ARE INCLUDED. (AUTHOR)

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CHAPTER I

INTRODUCTION

Background of the Problem

Mental retardation has long been recognized as a problem of major moral, social, and economic significance. In the United States, since the turn of the century, it has gradually acquired status as an issue of national concern (Masland, Sarason, and Gladwin, 1959). The growth of public interest is reflected, for example, in the enactment of the Barden-LaFollette Amendments of 1943 (Public Law 113), followed by the Vocational Rehabilitation Acts of 1954 (Public Law 565) and the far-reaching "Kennedy legislation" of 1963 (Public Laws 88-156 and 88-164).

Among the many consequences of these events is the attraction of increasing numbers of competent researchers to the study of mental retardation (Garrison, 1964). This, in turn, has led to an examination of research needs in relation to diverse aspects of the total problem.

Vocational training and prognosis of mentally retarded youth has emerged as a major area of focus; however, according to Windle (1962), much of the existing research in this area consists of poorly designed studies having limited generalizability. On the other hand, much of the more recent research, while demonstrating a high degree of methodological sophistication, is lacking in its relevance to important practical concerns (Gibson, 1964). There remains as Herber (1959) observes, a need for sound empirical research directed to applied problems.

This paper describes, in a limited sense, a research methodology which has the potential for direct application to applied questions and permits a systematic, scientific indentification and analysis of critical factors relating to these questions. This research was conceived as a part of a larger project demonstrating an experimental approach to the acquisition and analysis of vocational behaviors in severely retarded adolescents and adults.[1]

Research Model and Rationale

Inherent in any undertaking of this sort is the basic question of what plan of research best fits the problem. Some writers, for example Sanford (1965), advocate a holistic approach, perhaps at the expense of scientific rigor. Others, notably Skinner (1953), favor approximations of the methods of the natural sciences. One is frequently led, in reviewing these positions and their criticisms, to conclude that the researcher must make the choice of sacrificing either rigor or practicality in adopting a particular methodology.

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[1] This research was conducted at Fairview Hospital and Training Center, Salem, Oregon.

This would perhaps be true if one were to accept Sanford's contention that the work of Skinner and other behaviorists holds no practical value in the sense of "adding up" to a more complete understanding of the human organism and his environment (Sanford, 1965). However, the explicit principles derived from the more than three decades of Skinner's experimental analysis of behavior have been shown to have both prosthetic and therapeutic validity in application to complex human problems. With respect to the problem of mental retardation, for example, principles of operant conditioning have undergone a number of tests (Barrett and Lindsley, 1963; Bijou and Orlando, 1961; Binsberg, Colwell and Cassell, 1965; Birnbrauer and Lawler, 1964; Bullock and Maline, 1958; Ellis, Barnett and Prior, 1960). The results of these efforts have repeatedly demonstrated the validity and generalizability of the principles, but, more significantly, they have led to the discovery of weaknesses in techniques and procedures and to the formulation of extensions of the principles which show promise of greatly increasing their usefulness in the study of complex human behavior (Bijou, 1963; Blackwood, 1963; Garfunkel, 1964; Girardeau and Spradlin, 1964; Headrick, 1963; Linde, 1962; Lindsley, 1964; Staats, 1964).

The writer is of the opinion that this model has the potential of answering some of the criticisms posed by Sanford (1965) and others who share his views (i.e., it attempts a "systematization of a sort that would put particular facts in perspective and show their signficance") while retaining the scientific advantages of an atheoretical technology (Skinner, 1961).

This, of course, remains to be seen. It has been demonstrated, however, that these techniques and procedures hold considerable value as research tools in the study of certain classes of behavior.

Extension of the Model to Vocational Behaviors

Particularly in the case of the severely retarded, behavioral demands in typical vocational settings can readily be defined in terms of operants.[2] This can be accomplished through initially analyzing the particular task or set of tasks peculiar to the situation into a set of discrete components (Bray, 1962), and defining the specific behavior required to complete a task component as an operant. In this sense, the particular unit of behavior defined as the operant may consist either of a number of operant and respondent behaviors or of a single, simple action on the environment. The degree of specificity employed in defining the operants is then dictated by the degree of precision required in the analysis of the task behaviors, which in turn will be dependent on a variety of scientific and practical considerations.

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[2] The operant is defined by Skinner (1938, 1953, 1960) as an event occurring with a given frequency which is not observed to occur in relation to specifiable stimuli.

Having defined the task operants in this manner, it is then possible to make use of the various principles of operant behavior described by Skinner and others to facilitate the acquisition and maintenance of these behaviors under desired schedules. In most cases, this might conceivably involve the shaping of the individual components of behavior not presently in the subject's repertoire, followed by the conditioning of appropriate response chains through utilization of the principle of operant discrimination and the application of differential reinforcement. As the subject comes to consistently emit appropriately chained operants under the proper stimulus conditions (that is, he has learned the task), these behaviors can be maintained and appropriately manipulated with respect to rates through the application of selected schedules of reinforcement.

While the present research has dealt with a relatively limited sampling of vocational tasks, the implications of this procedure appear quite broad, in that the previous research (cited above and in the following section) suggests that a variety of behaviors in varying stimulus situations can be brought under the control of contingent reinforcement. That is, these same operant principles and procedures, or extensions thereof, should have a wide range of applicability in a variety of vocational environments.

Additionally, since it is possible to obtain direct measures of the specified behaviors under the prescribed conditions, continuous records of subject performance can be obtained for evaluative, prognostic, or program refinement purposes. For example, variations in environmental conditions or social structures could be studied with respect to their effects on predetermined operant rates. Data from such analyses could be used to construct prosthetic environments designed to produce optimal performance in a particular anticipated vocational placement or to provide a prognostic estimate of an individual's ability to function in such an environment. For research purposes, these effects, in combination with other measures (e.g., measured intelligence, age, etc.), could be used in complex experimental designs to obtain information, for example, concerning optimal combinations of tasks, environments, individual attributes, etc.

The research model involves the use of some of the more basic techniques of systems analysis in conjunction with operant conditioning principles and makes use of research designs presently available through electronic data processing. Such a model permits: (1) a systematic description of environmental demands and relevant behaviors, (2) explicit, direct measurement of critically relevant events. (3) introduction of discrete therapeutic and prosthetic treatments, (4) addition or control of a number of independent variables, and (5) simultaneous analyses of data with respect to the basic unit of behavior under study.

Statement of the Problem

On the basis of the above considerations, the choice was made to address this model to the study of vocational behaviors in severely retarded males. Specifically, the attempt was made to explore, first of all, the question of whether vocationally naive, severely retarded males could be shaped to perform selected vocational tasks. Secondly, the role of reinforcement in maintaining optimal levels of vocational behaviors was evaluated, holding certain variables of presumed relevance constant. Thirdly, the question of whether optimal combinations of task environments and treatments obtained was explored. Finally, as an addendum to the basic purpose of the research, an attempt was made to evaluate the generalizability and reliability of the operant techniques employed in the vocational settings with respect to the findings of previous research.

CHAPTER II

REVIEW OF LITERATURE

Operant Research in Relation to Vocational Training

While a number of studies are reported which demonstrate the efficacy of operant conditioning procedures in prosthetic and therapeutic applications (Bijou and Orlando, 1961; Ellis, Barnett, and Prior, 1960) and several researchers have reported their use in complex environments (Binsberg, Colwell and Cassel, 1965; Girardeau and Spradlin, 1964), reference to applications in vocational settings are apparently lacking.

A survey of literature has revealed only two papers which relate to this problem. Franks (1962) employed respondent conditioning procedures to derive indexes of vocational adjustment in retardates under the assumption that a general factor of conditionability obtains. Results of the research suggest that performance on standard conditioning tasks correlates well with ratings of vocational adjustment and certain related measures. Linde (1962), in a nontechnical discussion of training practices in a sheltered workshop situation, outlined several possible applications of operant procedures but cited no empirical evidence of their effectiveness. Certain of the procedures he recounted (e.g., the use of fixed-interval schedules of reinforcement) may, in fact, be suspected of having less efficiency than others which are available (e.g., fixed-ratio or variable ratio schedules, [Ferster and Skinner, 1957]).

Systems Analysis Research in Relation to Mental Retardation

Similarly, descriptions of the use of systems analysis as a technique for describing vocational tasks and environments are plentiful, particularly in the literature relating to industrial and military applications (March and Simon, 1958), although references to its application in the area of mental retardation are limited. Only one article (Silvern, 1963) has been located which deals with this problem. In this example, a procedure termed object analysis was used to identify task components in much the same manner as proposed above. From this, experimental lessons somewhat similar to an instructional program were constructed as a means of training a group of retardates to perform a television antennae assembly task. The Work-Sample method of vocational training (Burdett, 1963) also incorporates some of the attributes of systems analyses and is in certain ways similar to the methods of the proposed research. However, the behavioral descriptions obtained through this approach are of little technological value (Usdane, 1959).

Contemporary Approaches to Vocational Training and Prognosis

Each of these procedures, however, appear to have distinct advantages over the more typical vocational training programs which are commonly classified in terms of generically defined vocational activities and abstract variables germaine to the evaluation of vocational performance and prognosis (Baer, 1960; Boley, 1956; Burdett, 1963; Cohen and Williams, 1961; Schwartz, 1958). A previous report of the present writer (Crosson and Leland, 1965) describes a similar program in which an attempt was made to define procedures and objectives somewhat more explicitly and to effect a more systematic application of available treatment and training modalities. The results, however, fall short of the objectives made possible under the proposed system.

Possibly as a result of this lack of preciseness, and in some cases because of apparent error in the measures employed or faulty research design, literature relating to the vocational prognosis of retardates yields conflictual information, as is pointed out by Windle (1962) in his comprehensive review of research. Although the employment potential of the mentally retarded has been recognized, in the empirical sense, since the 1940's (Hegge, 1944; Himmelweit and Whitfield, 1944), and the feasibility of retarded employment has repeatedly demonstrated (Phelps, 1965; Strickland, 1964), attempts to identify factors bearing a causal relationship to placement adjustment have met with little success. At this writing, only two such factors appear to emerge consistantly, i.e., intelligence test scores and, in the case of institutionalized persons, admission age (Appell, 1964, 1965; Madison, 1964; Windle, 1962).

Vocational Potential of the Severely Retarded

The present research has dealt with a particular subgroup of the mentally handicapped referred to as being "severely retarded." These individuals are defined under the technical language of the American Association on Mental Deficiency (Heber, 1959) with respect to intelligence quotients, obtained through administration of acceptable standardized instruments, which fall within the range of four to five standard deviations below the population mean. The selection of this type of individual, which occurred somewhat by accident through adherance to the sampling of vocationally naive subjects, gave rise to some interesting implications.

In the United States, such individuals have traditionally been considered subtrainable, and as Sarason (1959) has indicated: "with such individuals the intelligence or developmental quotient has not only exempted them as subjects of psychological research, but it has also served as an effective barrier against innovations in training and treatment."

However, this state of affairs has not prevailed in other countries. For example, Clarke and Hermelin (1955) published an article which indicated some rather surprising abilities present in a population of adult imbeciles. Similar observations are presented in a book by O'Connor and Tizard (1956).

Another report by Loos and Tizard (1955) described the employment of adult imbeciles in a hospital workshop, which has many similarities to the vocational environment involved in the present research. A few other, more general reports are also available concerning training and employment practices for the severely retarded in Europe (Wortis, 1961; Wolfensberger, 1964).

In contrast, only one study was located which surveys this problem in the United States. Asenger (1957), in his impressive presentation of research on a sample of "severely retarded" individuals who had previously been enrolled under the New York state public school system, reported that as high as 36% of his sample had demonstrated some acceptable degree of vocational adjustment.

A Prognostication

While it should be mentioned that most of the retardates referred to in this body of literature were not strictly classifiable as severely retarded under the AAMD definition, there were in all cases at least a few individuals who did fall within this category. On this basis then, while the literature does not entirely support the notion that individuals with I.Q.'s below 30 are capable of adequate performance in prescribed vocational environments, the evidence does seem to suggest that the probability of this obtaining is not to be discounted. As will be seen later, this assumption received unquestionable support through the results of the present research.

There is little doubt that the more precise indentification, control and analysis of critical variables available through the model employed in this limited research has greatly aided the attainment of these results. But of far greater importance, it is conceivable that continued extensions of these principles will lead to a precision of scientific description and explanation exceeding the limits of contemporary research. While a test of this assumption is much beyond the scope of this paper, the results described herein have added another limited indication of the efficacy of Skinner's goal (1961, p. 69).

CHAPTER III

RESEARCH METHODOLOGY

General Experimental Design

Working from a population of vocationally naive, severely retarded, institutionalized patients, an attempt was made to devise programs for the training of subjects on selected workshop tasks. A modified form of task analysis was employed to describe the vocational environments and to specify behavioral components critical to the performance of the tasks. Utilizing the specified behavior topographies as the instructional units, training programs based upon principles of shaping, operant discrimination, and chaining of responses were then devised.

It was assumed that this incorporate approach would lead to more precise indentification, control, and analysis of critical vocational behaviors than has been possible in previously reported mental retardation research.

A research paradigm was then devised to test the general hypothesis that the combination of techniques described above can provide an effective approach to the production and maintenance of vocational behaviors in the mentally retarded. More specifically, a general experimental design was developed to permit empirical test of: (1) whether vocationally naive, severely retarded adolescent and adult males could be trained by the use of these procedures to function effectively in prescribed vocational settings, (2) the value of reinforcement in maintaining previously acquired behaviors, and (3) whether behavioral predictions based on previous operant research are valid in the prescribed setting.

The research procedures were organized into three sequential phases. The first of these involved a set of preliminary operations which included the selection and arrangement of experimental tasks and environments, fofowed by the analysis of these tasks into separate components leading to the specification of task operants, and the development of training procedures. The second phase was directed to an experimental analysis of response acquisition characteristics which obtained under the experimental programs. The third phase of the research involved an analysis of the comparative efficiency of different reinforcement contingencies in controlling the behaviors of pre-trained Ss while exposed to the experimental environments.

Data obtained under phase two of the research were used to construct acquisition curves and other descriptive indexes of the efficacy of the experimental training procedures. Phase three data were analyzed under a two-way analysis of covariance design, using operant measures as the dependent variable with covariance adjustments for the effects of predictor variables identified in the preceding experiment.

Population and Samples

The research population was composed of all male patients currently in residence at Fairview Hospital and Training Center who were between the ages of 18 and 30 and were free of debilitating physical anomalies or severe behavioral disorders. In addition, it was required that the patients should have no history of previous vocational training or experience.

Due to an existing Fairview policy of providing some type of work experience for all patients who meet minimal standards of vocational potential, this latter sampling restriction reduced the number of subjects available for this research to a total of 64 patients classifiable as severely retarded. Intelligence test scores for these 64 patients yielded a mean I.Q. of 24 with a range of 11 through 42. The subjects ranged in age from 18 through 30 years with a group average of 23 years. The mean admission age was ten years with a range of one through 25 years.

Three Ss, whose I.Q.'s and ages approximated the means of the total group, were selected for use in the preliminary phase of the research. A total of 34 Ss were then randomly drawn from the remaining members of the group. A random selection of ten were then assigned to the phase two sample, and the remaining 24 were randomly assigned in equal numbers to the phase three experimental and control groups.

During the course of the study, two subjects were lost from the sample assigned to the second phase of the research. One was excluded because of severe motor impairment which precluded his performance in the experimental environments and the second due to sustained failure to obtain stimulus control over his behavior. Additionally, drilling task data for a third subject was discarded as a result of inadvertently employing improper training procedures.

Again due to failure to attain stimulus control, one subject was also lost from the phase three control group. In order to compensate for the reduction in sample size, one randomly selected subject was deleted from the phase three experimental group.

Demographic data for these groups (excluding the lost _Ss_) are shown in Tables I, II, and III. A series of _t_ tests yielded results which indicated that the groups did not differ significantly with respect to age, I.Q., or admission age (see Table IV).

Experimental Tasks, Operants, and Instrumentation

The three experimental tasks were selected from a variety of typical work assignments available in the general

TABLE I

Distribution of Age, I.Q., and Admission Age for Phase Two Sample

Subject	Age	I.Q.	Admission Age
1	18	34	5
2	19	26	19
3	18	20	17
4	19	25	7
5	27	32	16
6	25	16	10
*7	21	31	2
8	30	30	25
ΣX	177	214	101
ΣX^2	4065	5998	1709
$\bar{X}$	22.12	26.75	12.62
S^2	21.27	39.07	61.98
*$\bar{X}$	22.29	26.14	14.14
*S^2	24.57	42.14	50.80

---

*The asterisks denote the S lost from the Task I sample due to the use of inappropriate procedures and the adjustment sample mean and variance, which did not differ significantly from the original statistics.

Distribution of Age, I.Q., and Admission Age for Control Group

Subject	Age	I.Q.	Admission Age
1	20	39	16
2	19	20	13
3	22	19	4
4	19	12	3
5	24	16	5
6	18	21	2
7	20	23	14
8	24	19	13
9	21	29	11
10	30	16	14
11	20	41	14
ΣX	237	255	109
ΣX^2	5223	6791	1357
$\overline{X}$	21.54	23.18	9.91
S^2	11.67	87.95	27.69

TABLE III

Distribution of Age, I.Q., and Admission Age for Experimental Group

Subject	Age	I.Q.	Admission Age
1	18	29	7
2	24	25	18
3	27	15	8
4	23	27	14
5	18	28	12
6	20	20	17
7	23	30	10
8	25	24	1
9	20	14	2
10	29	21	13
11	27	15	8
ΣX	254	248	110
ΣX^2	6006	5942	1404
$\overline{X}$	23.09	22.54	10.00
S^2	14.09	35.07	30.39

TABLE IV

Comparisons of Phase Two, Control and Experimental Groups with Respect to Age, I.Q., and Admission Age

Groups	S^2	N	$\bar{X}$	d.f.	*t*	*p*
			Age			
Phase Two	21.27	8	22.12	7	.305	>.70
Control	10.63	11	21.54	10		
Phase Two	21.27	8	22.12	7	1.009	>.30
Experimental	14.09	11	23.09	10		
Control	10.63	11	21.50	10	1.075	>.30
Experimental	14.09	11	23.09	10		
			I.Q.			
Phase Two	30.07	8	26.75	7	1.048	>.30
Control	81.29	11	23.08	10		
Phase Two	39.07	8	26.75	7	1.483	>.10
Experimental	35.07	11	22.54	10		
Control	81.29	11	23.08	10	.356	>.70
Experimental	35.07	11	22.54	10		
			Admission Age			
Phase Two	61.98	8	12.62	7	1.155	>.20
Control	25.98	11	9.00	10		
Phase Two	61.98	8	12.62	7	.808	>.40
Experimental	30.39	11	10.00	10		
Control	25.98	11	9.00	10	.160	>.80
Experimental	30.39	11	10.00	10		

program of the Fairview pre-vocational workshop. While various practical and economic considerations entered into the final selection, care was taken to insure that each of the tasks, while phenotypically dissimilar, were correlated with respect to physiological demands. Specifically, each task was characterized by a predominance of response topographies associated with extensor and flexor reflexes of the upper extremities.

The selected tasks were: (1) a machine operation for the manufacture of wooden pencil holders, (2) a prefinishing operation which involved smoothing wooden blocks with sandpaper, and (3) a light assembly operation involving the manufacture of wooden flower baskets.

The basic tasks were initially analyzed into a set of discrete components; these were evaluated in terms of known or assumed limitations in the behavioral repertoires of the research population. Initial adjustments were then made in the task demands through increasing the number of task components, adding or substituting response topographies, and introducing jigs and other devices designed to limit the response characteristics to simple motor behaviors.

The modified tasks were then re-analyzed into component units, and a taxonomy of correlated response topographies was written for each. One of three preselected, nonexperimental Ss was systematically exposed to the individual components of the modified task, and attempts were made to shape the correlated behaviors. This permitted relatively detailed analyses of the discriminative values of the various component stimuli and the response characteristics of the subject.

The resultant information led to further modifications in the task environments. For example, one adjustment involved changing the arc of rotation of the drill press lever to maximize extensor movements in order to limit the effects of an apparent defect in flexion control observed in the pre-experimental S and a number of other severely retarded patients. Another involved painting the various parts of the jigs in sharply contrasting colors as a means of enhancing the discriminative properties of the sequentially altered stimulus configurations of the task environments.

The tasks were again re-analyzed, and the response taxonomies rewritten to conform to these adjustments. The final versions of the response topographies for Tasks I and III are presented in Appendices A and B, respectively. The topography for Task II is not included since, following modification, the task environment required only the repetition of a single basic response (i.e., moving the unfinished block back and forth across a specially designed sanding board).

Operants were specified in two ways according to the requirements of the experimental procedures which followed. For the initial experiment, analyses of response acquisition characteristics required measures of responses to each of the individual stimulus components of the experimental tasks, thus the measures were based on the correlated response topographies, and the operants were therefore defined with respect to some readily identifiable behavioral unit of each topography. Task II (sanding operation) was defined in terms of a single operant, the return stroke on the sanding board. In contrast, Task I and III were defined in terms of 103 and 111 operants, respectively (see Tables A and B).

The second experiment was concerned with behavior maintenance data rather than with response acquisition measures (i.e., performance rather than training). Thus, in recognition of the fact that the typical workshop and other vocational settings lack facilities for the measurement and control of discrete units of behavior, the decision was made to devise a more practical and expedient system of performance analyses than was required in the recording of discrete response units.

The system adopted for this research is based upon logical criteria for the evaluation of work performance. More precisely, measures were based on the "critical" components of the respective tasks. For example, it was assumed that in practical application, an employer might evaluate the worker's performance on the drilling task on the basis of the number of holes drilled per unit time.

"Critical task operants" (in contrast to the unit operants described above) were thus specified in terms of behavior required to produce the holes, that is, the movement of the drill press lever through its prescribed arc.

Similarly, evaluative criteria for Task III would include, in addition to the number of units completed per unit time, an assessment of the precision of aligning the parts and the accuracy exercised in installing the nails. The critical task operants for this sequence were then defined in terms of the behaviors involved in the alignment of the wooden strips in the jig, and the installation of the nails; that is, (1) abutting the slats against the sides of the jig, (2) the final stroke in driving the first nail, and (3) the final stroke on the last nail. (Note: the critical task operants are indicated by asterisks preceding the position number of the topographies in Appendices A and B.)

In order to facilitate the analysis and control of the subject's behavior in the experimental environments and to limit the number of distracting stimuli, each of the work stations was arranged around an experimental cubicle in such a way as to be effectively screened from each of the other work stations in the building and conveniently exposed to view through one-way mirrors installed in the walls of the cubicle. (A diagram of this arrangement is presented in Appendix C.)

The interior of the cubicle housed the observer stations, in-process data storage facilities, and the timing, recording, and contingency programming apparatus. Instrumentation was designed to permit the monitoring of subject behaviors from within the cubicle or by remote devices located at the respective work stations.

Experimental Procedures: Training

Having analyzed the respective tasks into component units, specifying the correlated response topographies, and redefining the task in terms of operants, it was then possible to devise a set of training programs. This was accomplished by use of the principles of shaping, operant discrimination, and chaining of responses. The result was, in effect, a modified version of a linear instructional program with the individual stimulus components of the tasks serving as the "frames." In keeping with the theme of practicality as dictated by typical workshop facilities, the programs were devised to use human rather than mechanical programmers.

In initiating the training sequences, the experimenter demonstrated each of the component behaviors individually and caused the subject to immediately model that behavior. In most instances, this was accomplished through verbal or gestural command, although occasionally it was necessary to "mold" the response by physically guiding the S through an approximation of the appropriate topography. This shaping process was continued with successive approximations of the specified operants being reinforced on a CRF schedule.

As the individual operants were shaped (many, incidentally, were already available in the subject's repertoires), the subject continued responding under the sequentially ordered stimulus components until the correlated stimulus configurations appeared to have acquired the properties of discriminative stimuli.

At this point, the experimenter-produced "cues" were gradually faded through a process of simply altering demonstrations from overt behavior to faint gestures to the total withholding of responses. At this latter stage, the S's behavior could be technically described as a set of chained responses.[1]

Throughout the training, the reinforcement schedule was altered with the acquisition of each discriminated operant. That is, once the subject's response appeared to be under the control of the correlated task stimulus, food reinforcement was terminated for that response; thus, as the number of discriminated operants increased, a chained schedule was introduced.[2] At criterion level, the subjects were on a chain FR schedule with food reinforcers contingent on the emission of the critical task operants only.

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[1] A response chain is defined as a sequence of responses in which one response produces conditions essential to the next, as in making the next response possible or more likely to be reinforced. (Ferster and Skinner, 1957).

The training procedures were developed and perfected through a series of trials using the three non-experimental subjects. The same programs, with minor differences in reinforcement procedures, were then employed in the training of the experimental Ss for both the response acquisition and the behavior maintenance studies.

Under the first experiment, ten randomly selected Ss were systematically exposed to the training programs on a schedule of consecutive daily, 20 minute periods to a criterion of two perfect trials within a given session. Reinforcement, which consisted of M & M candies combined with verbal and other forms of social reinforcement, was administered as described above. Immediately following the obtainment of criterion level, the subjects were run for two days on standard work (minimum supervision) conditions under a delay (end of session) reinforcement schedule.

Approximately 60 days following the termination of the experiment, the Ss were again exposed to Task I under post-training conditions, and retention data based on the subject's performance on the initial two trials were obtained.

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[2] Ferster and Skinner (1957) define a chained schedule as one in which a response to one stimulus configuration on a given schedule is reinforced by the production of a second stimulus in the presence of which a response is reinforced on a second schedule with food, etc. (i.e., the reinforcement of the first component is simply the production of the stimulus of the second component).

Data for the experiment were obtained with the assistance of an observer stationed in the experimental cubicle. Response acquisition data were obtained on the basis of the number of discriminated operants emitted by trials within sessions. For the two post-training sessions and the retention study, measures were based on the number of critical task operants emitted by sessions and by trials, respectively.

Experimental Procedures: Performance

In order to further evaluate the effectiveness of operant conditioning principles in vocational environments, a second study was designed to test the effects of reinforcement schedules upon the maintenance of previously acquired behaviors. Twenty-two *S*s were randomly assigned to control and experimental groups and systematically trained on the two experimental tasks employed on the initial study (Tasks I and III) and were additionally shaped to the previously described sanding task (Task II). The training procedures employed with these subjects were identical to those described in the preceding section, with the exception that verbal praise and other forms of social reinforcement replaced the primary (food) reinforcement.

Following training, both groups were continued on the experimental tasks for a series of ten daily, 24 minute "work" sessions. The control group was maintained on a nonspecified contingency of social reinforcement which was assumed to be characteristic of typical workshop environments, while the experimental group was placed under the control of prescribed reinforcement schedules which were assumed to maximize the probability of obtaining high and stable response rates.

English half-pennies were employed as secondary reinforcers to be exchanged for a variety of candies, toys, and trinkets at a "store" set up near the experimental area.

Following training, and preceding the performance trials, the experimental Ss were shifted to simple discrimination task using a modified version of the Wisconsin General Test Apparatus in order to insure equivalent amounts and formats of exposure to the tokens and to limit the possible effects of additional practice on the experimental measures. The standard paradigm of pairing primary reinforcers (M & M's) with the unconditioned stimuli (tokens), followed by the fading of the primary reinforcers, was employed to shape the Ss to respond to the English half-pennies as conditioned reinforcers. This procedure interrupted the subject's performance on the tests the equivalent of one and one-half sessions.

It will be recalled from the earlier discussion of experimental tasks that the sanding operation involved the continuous repetition of a single response topography. The drilling task, in contrast, involved the chaining of approximately 14 operants (reinforced by the sequential response produced alterations of the stimulus configurations), interposed by a single response reinforced by food or other reinforcer. The basket assembly, on the other hand, was described as a chain of four operants interposed by three consecutively reinforced responses (although this pattern varied somewhat within the chain).

These contingencies were adjusted on the basis of the control group data in order to provide approximately equal magnitudes of reinforcement for each task. In making the adjustments, an attempt was made to select schedules which would preclude the reinforcing of two or more consecutive responses and yet limit the likelihood of obtaining a ratio strain.

A simple FR 24 schedule was employed for Task II, while a chain FR 1_1 FR 1_2 --- FR 1_{14} and a chain FR 1_1 FR1_2 --- FR1_4 FR 4 were employed for Task I and Task III, respectively.

Data for both the control and experimental groups were obtained with the assistance of observers positioned in the immediate vicinity of the respective work stations. Remote switching devices were employed to operate digital counters which totaled the number of critical task operants by sessions. Reinforcement schedules for the experimental group were controlled by contingency programmers which were also operated by the remote switching devices.

During both the training and experimental phases of the experiment, randomly selected triads were brought to the experimental environments for 90 minute periods. The individual members of each triad were randomly assigned to counterbalanced sequences of 24 minute sessions, each session being interposed by a six minute rest period.

CHAPTER IV

DATA AND ANALYSES

Acquisition of Operants and Formation of Response Chains

The basic question at issue in this research concerns the efficacy of extending operant conditioning principles to the area of vocational training with the mentally retarded. Phase two of the research was, therefore, devoted to an exploratory analysis of the acquisition of prescribed vocational behaviors by a sample of vocationally naive, severely retarded subjects under the experimental training programs described previously.

The response acquisition curves for the individual subjects on Task I (the machine operation) are shown on Figure I. The line graphs depict the percentage of the total number of responses controlled by the appropriate stimulus components of the chain as a function of the number of trials.

Assuming a zero point relative to the number of operants emitted under the stimulus configuration immediately preceding the first trial, it can be seen that the majority of the subjects achieved at least 90% of criterion level

FIGURE I a

Percentage of Discriminated Operants by Trials: Task I

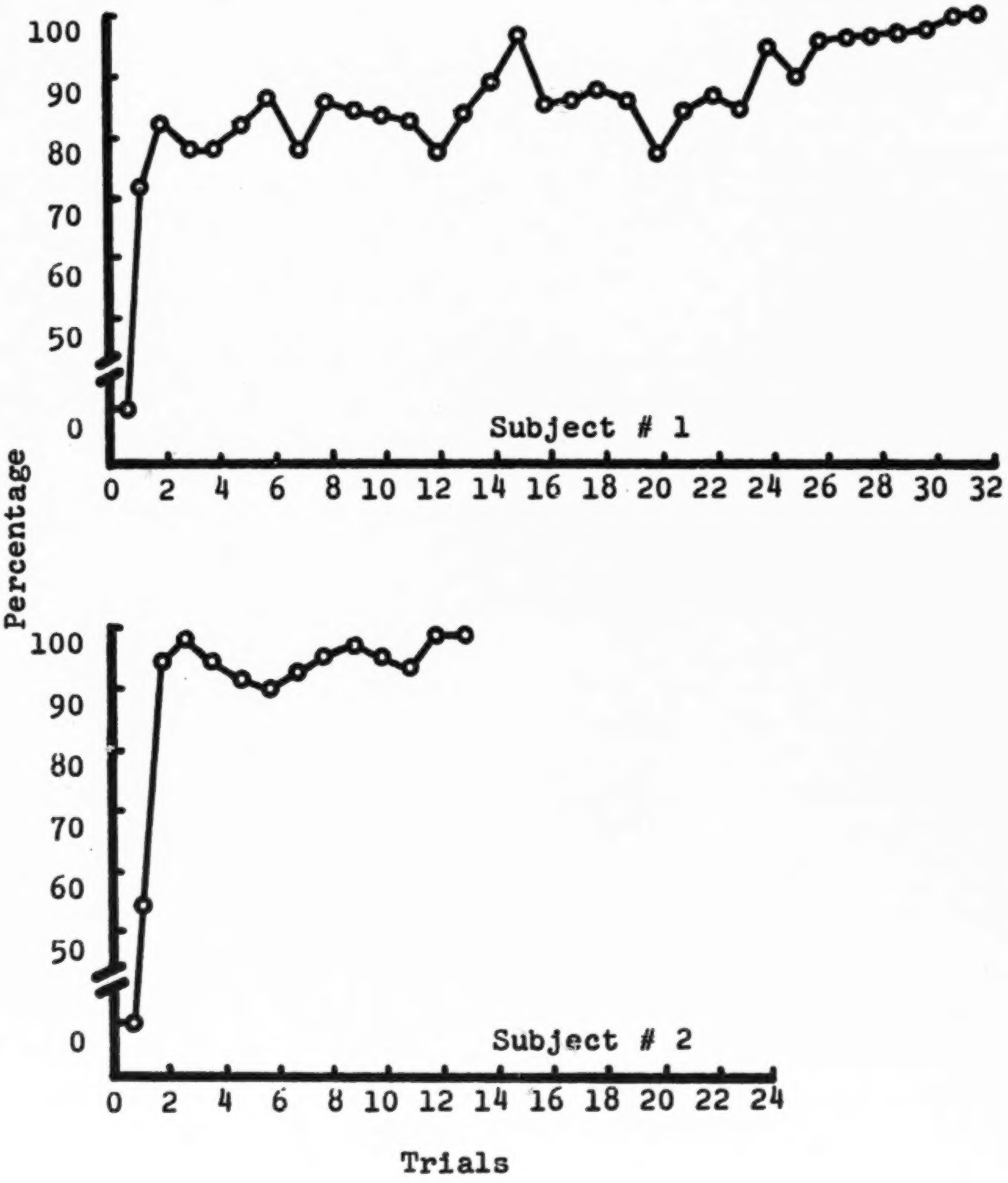
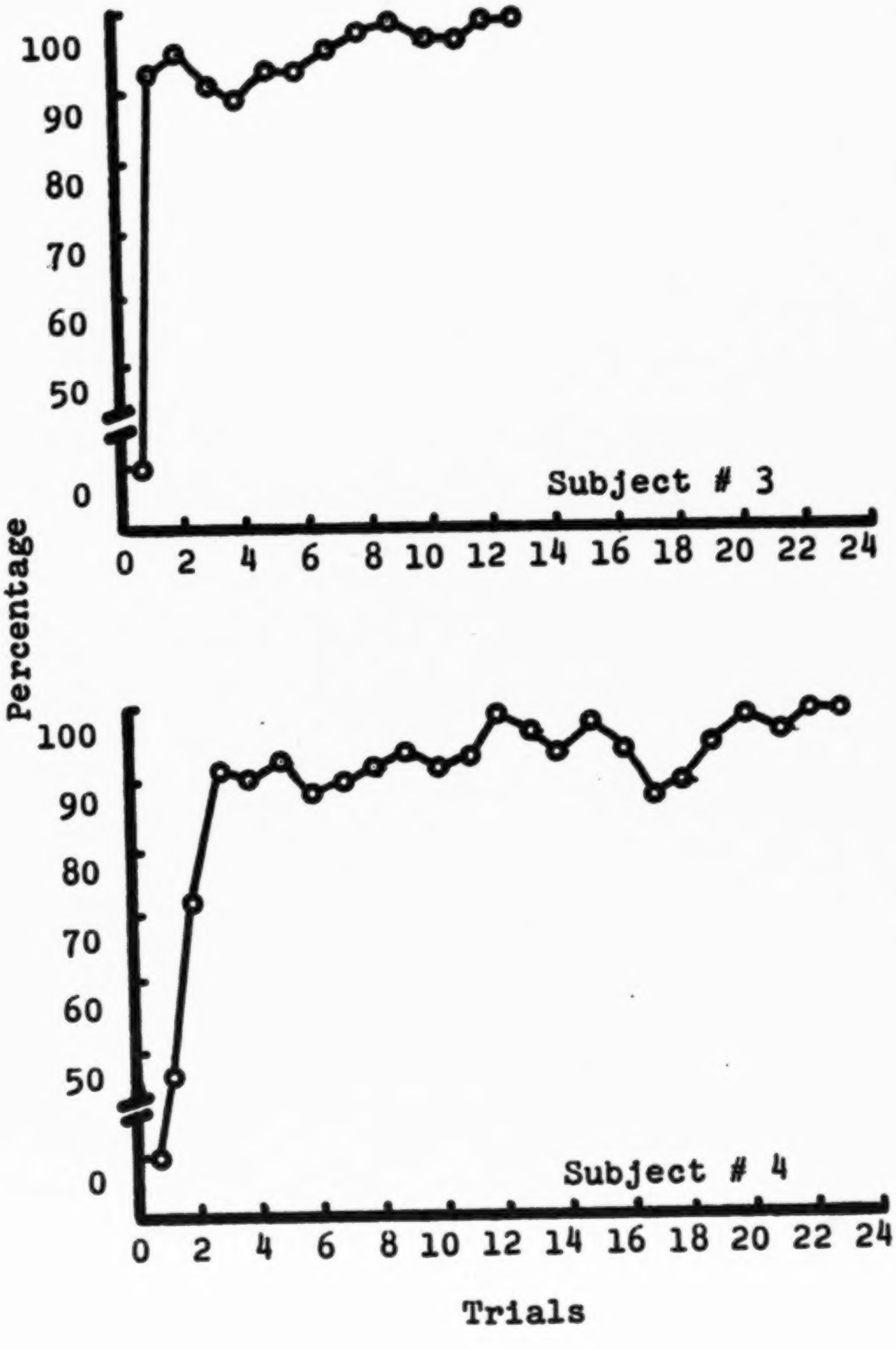


FIGURE I b


100
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Subject # 3
0 2 4 6 8 10 12 14 16 18 20 22 24
Percentage
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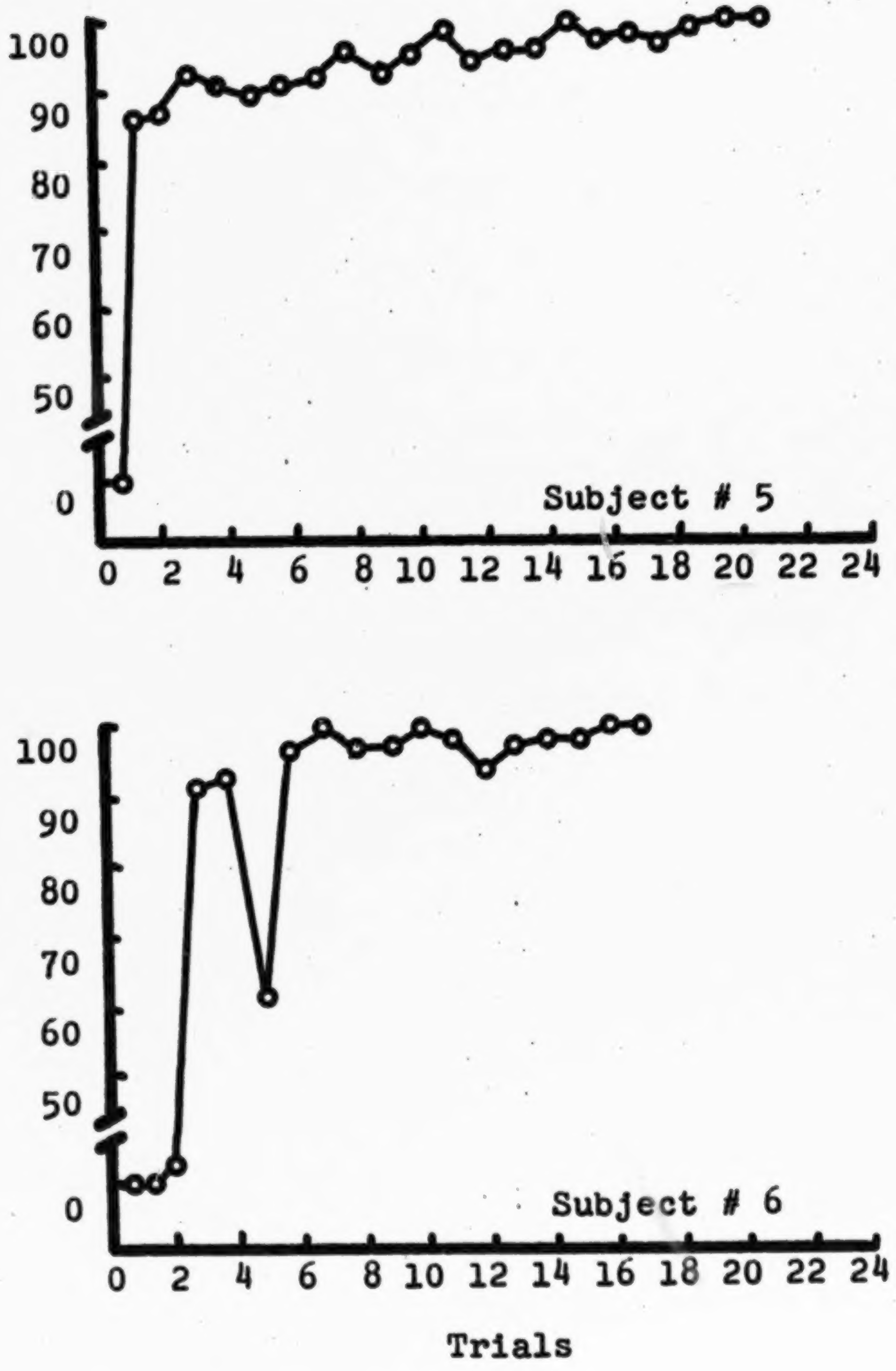
Subject # 4
0 2 4 6 8 10 12 14 16 18 20 22 24
Trials

FIGURE I c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Subject # 5
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Subject # 6
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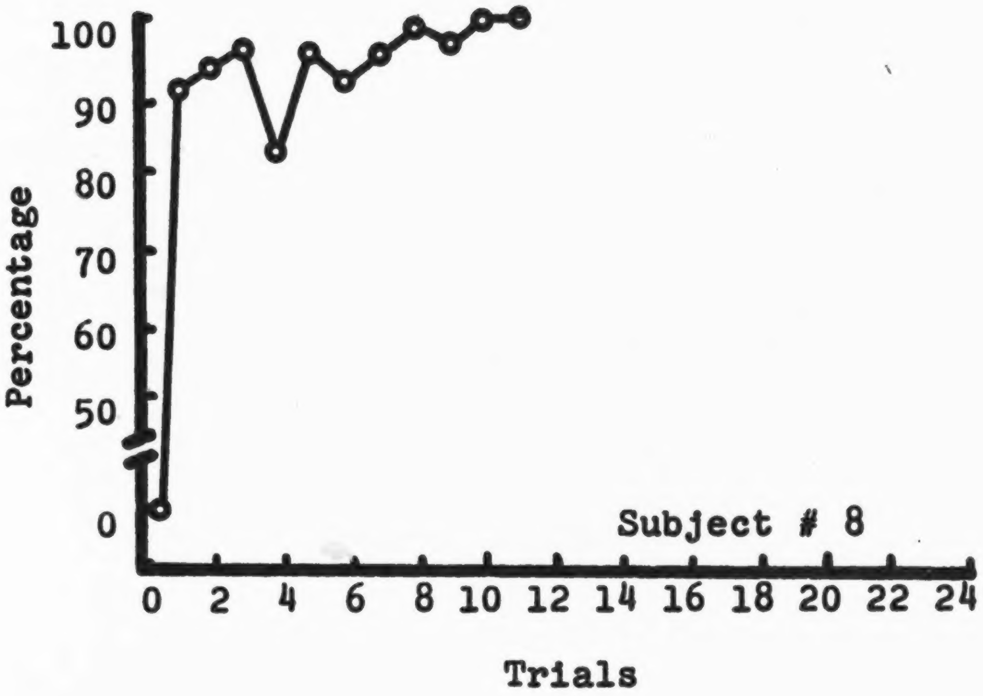
Trials

FIGURE I d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Percentage
Subject # 8
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4
6
8
10
12
14
16
18
20
22
24
Trials

within four trials. The rapidity with which this level was attained would suggest: (1) that most of the essential behaviors were already available in the subject's repertoires prior to the initiation of the training procedures and (2) that the experimental procedures possessed a relatively high level of efficiency in establishing the response chain.

Inspection of the individual curves reveals a tendency for a reduction in the percentage of discriminated operants immediately following early high acquisition levels. Recalling from Chapter III, each response was reinforced individually during shaping with primary reinforcement being withdrawn as the responses were brought under the control of the appropriate discriminative stimuli (with the exception of selected "critical" operants). This procedure, in effect, constituted a shift from CRF to an FR schedule of reinforcement. The assumption, then, is that the early drop in acquisition level reflects a partial extinction, specifically extinction of control by the initial CRF schedule (Ferster and Skinner, 1957, p. 42). This extinction effect was much stronger for Subject #6, who had been on a CRF schedule for three trials prior to the shift, than for subjects 3, 5, and 8, who had only one CRF trial. Subjects 1 and 4, due to the necessity of prolonged shaping, underwent a more gradual shift to the final chained schedule. Partial extinction for these two subjects was delayed, but nevertheless evident following the initial peak in the acquisition curve.

Following the extinction effect, the curves for all subjects reflect a gradual return to criterion level. Since, in a chained schedule, each component stimulus presumably functions as a discriminative stimulus for the following response and as a conditioned reinforcer for responding in the component which precedes it, this effect is typically assumed to reflect both the refinement of stimulus control and the rate at which the stimulus components acquired secondary reinforcement properties.

The same general effects are reflected in the acquisition curves for Task III (Figure II). However, fewer trials were required for the acquisition of criterion level than in the case of Task I. This effect is assumed to be due to differences between the two tasks with respect to spacing of primary reinforcement under the chained schedules. Task I involved a heterogenous chain (Kelleher and Gollub, 1962) of 14 responses, followed by a 15th response reinforced with food, while Task III incorporated a chain FR 1 FR 1 FR 1 CRF schedule during the training procedure.

The spacing of primary reinforcement under the Task III schedule is, thus, quite small (see Appendix B), while the spacing is relatively large for Task I (see Appendix A). Since this requires, in the former case, that fewer of the stimulus components must acquire secondary reinforcing

FIGURE II a

Percentage of Discriminated Operants by Trials: Task III

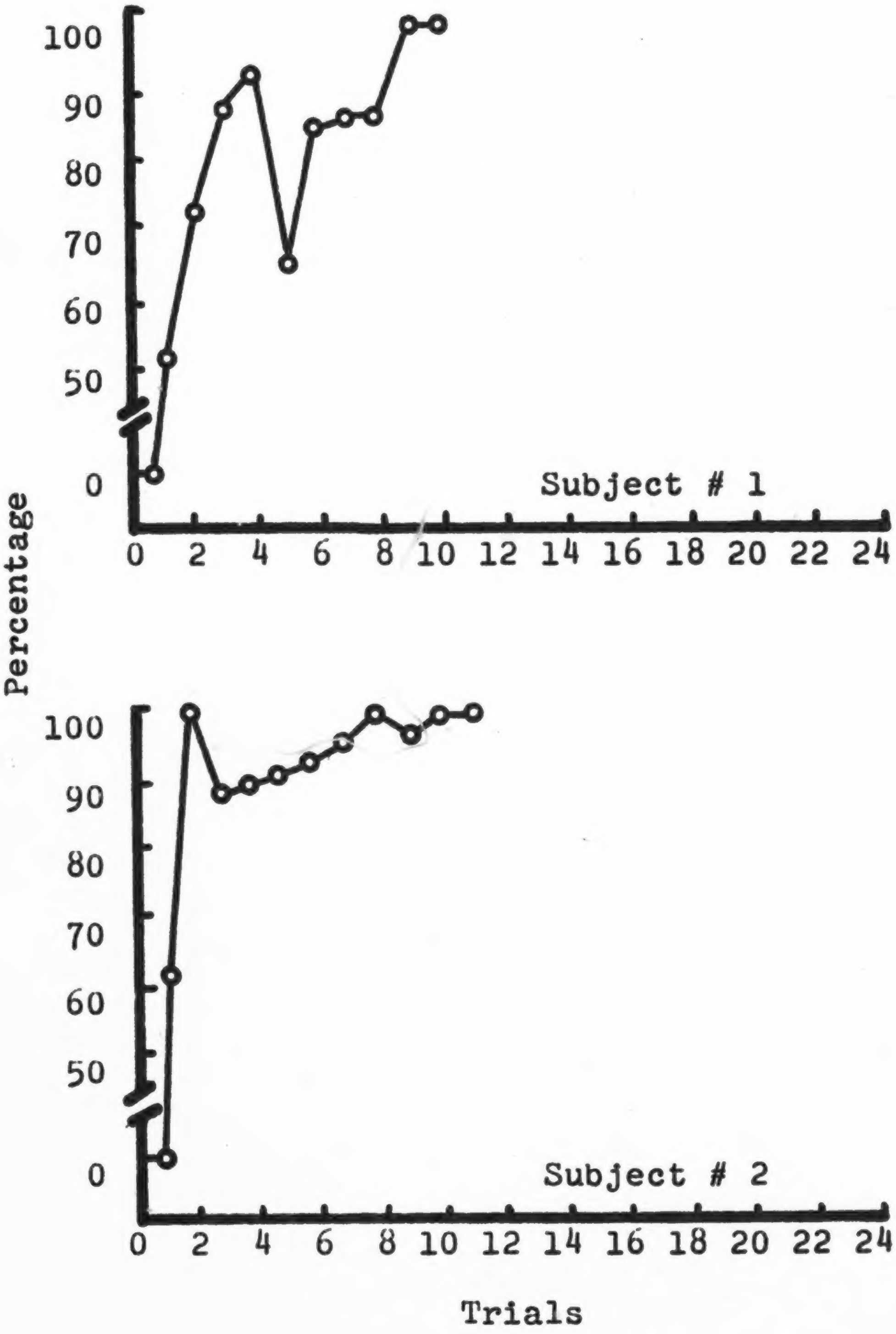
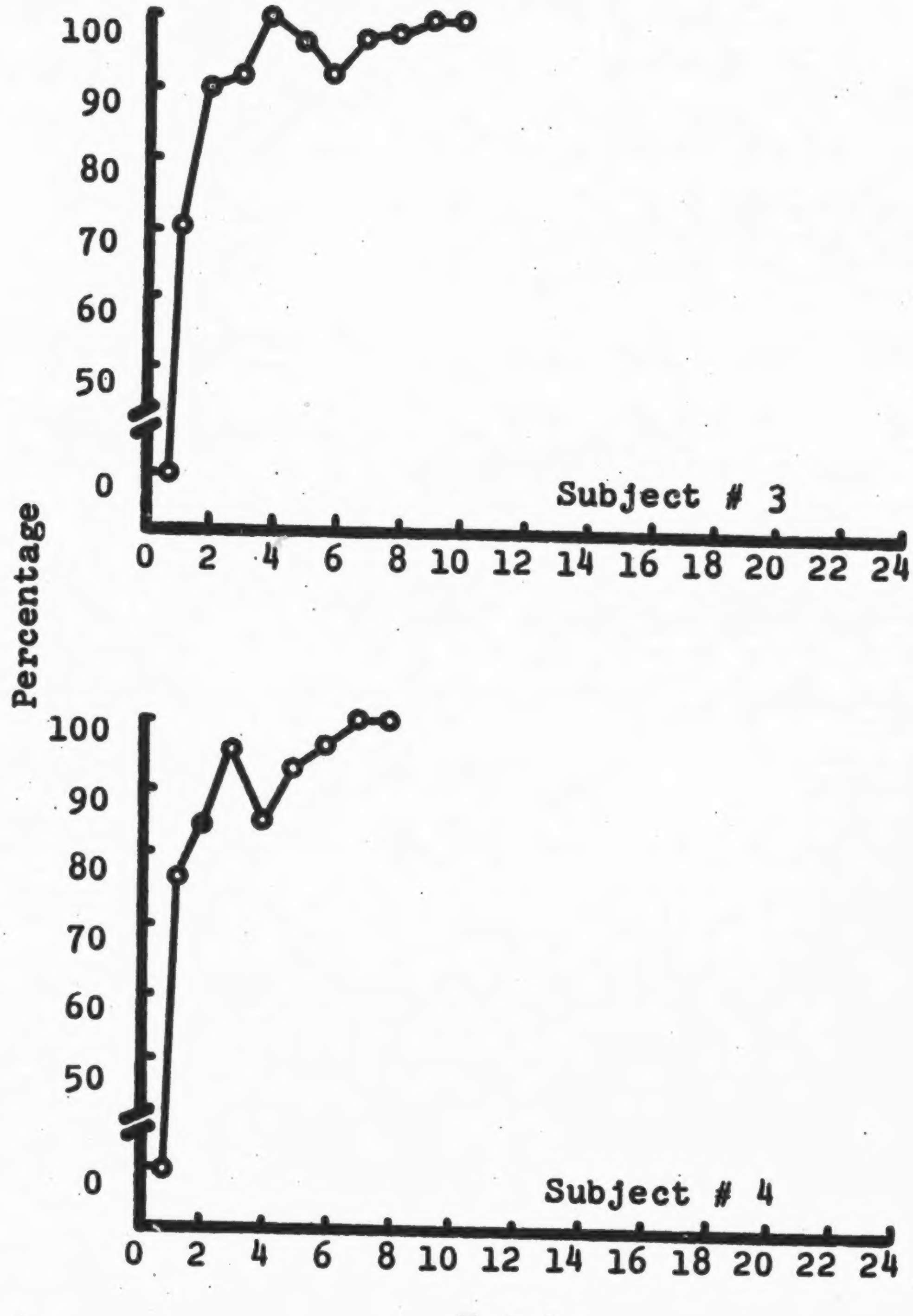


FIGURE II b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Subject # 3
0 2 4 6 8 10 12 14 16 18 20 22 24
Percentage
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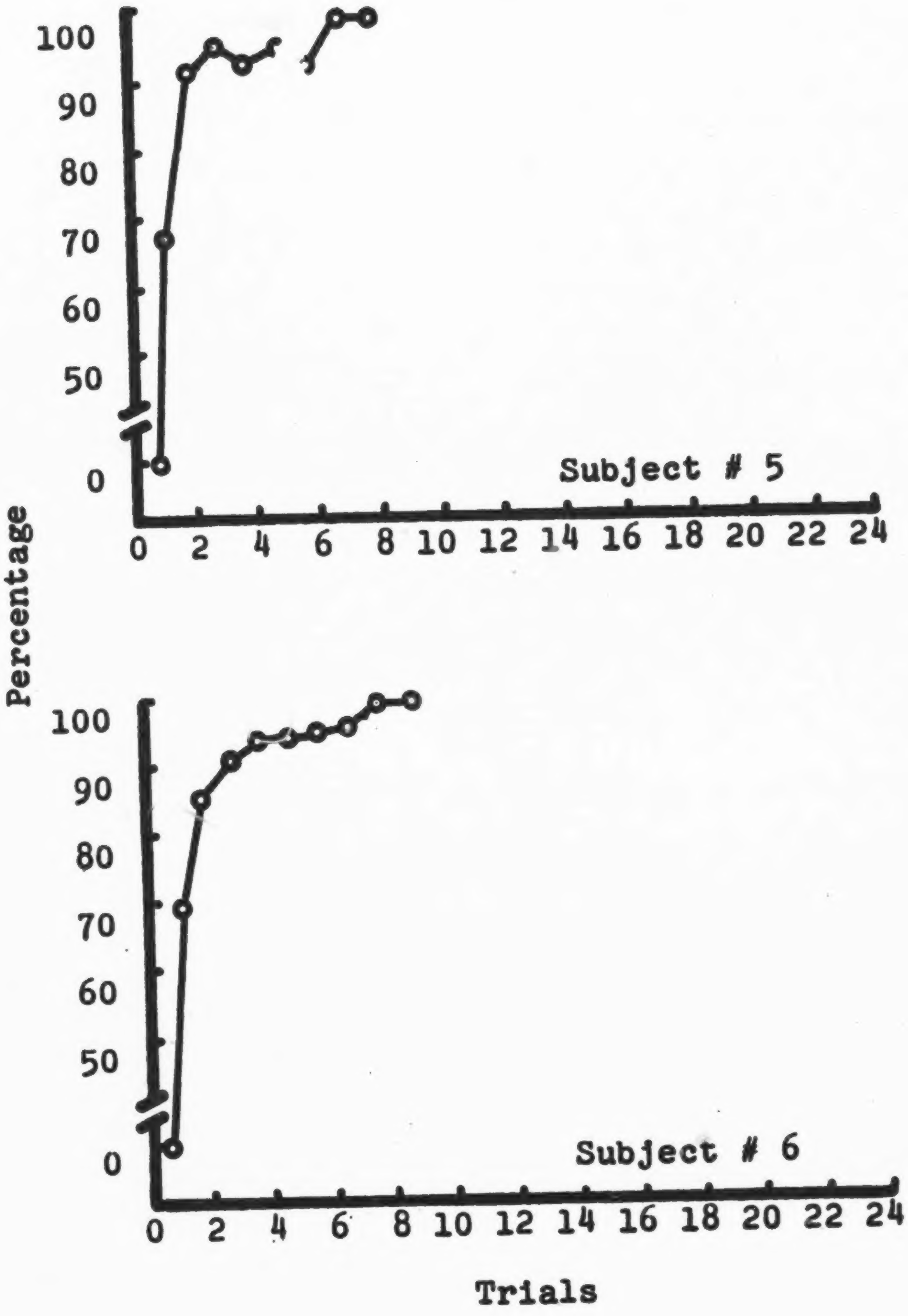
Subject # 4
0 2 4 6 8 10 12 14 16 18 20 22 24
Trials

FIGURE II c


Percentage
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Subject # 5
0 2 4 6 8 10 12 14 16 18 20 22 24
100
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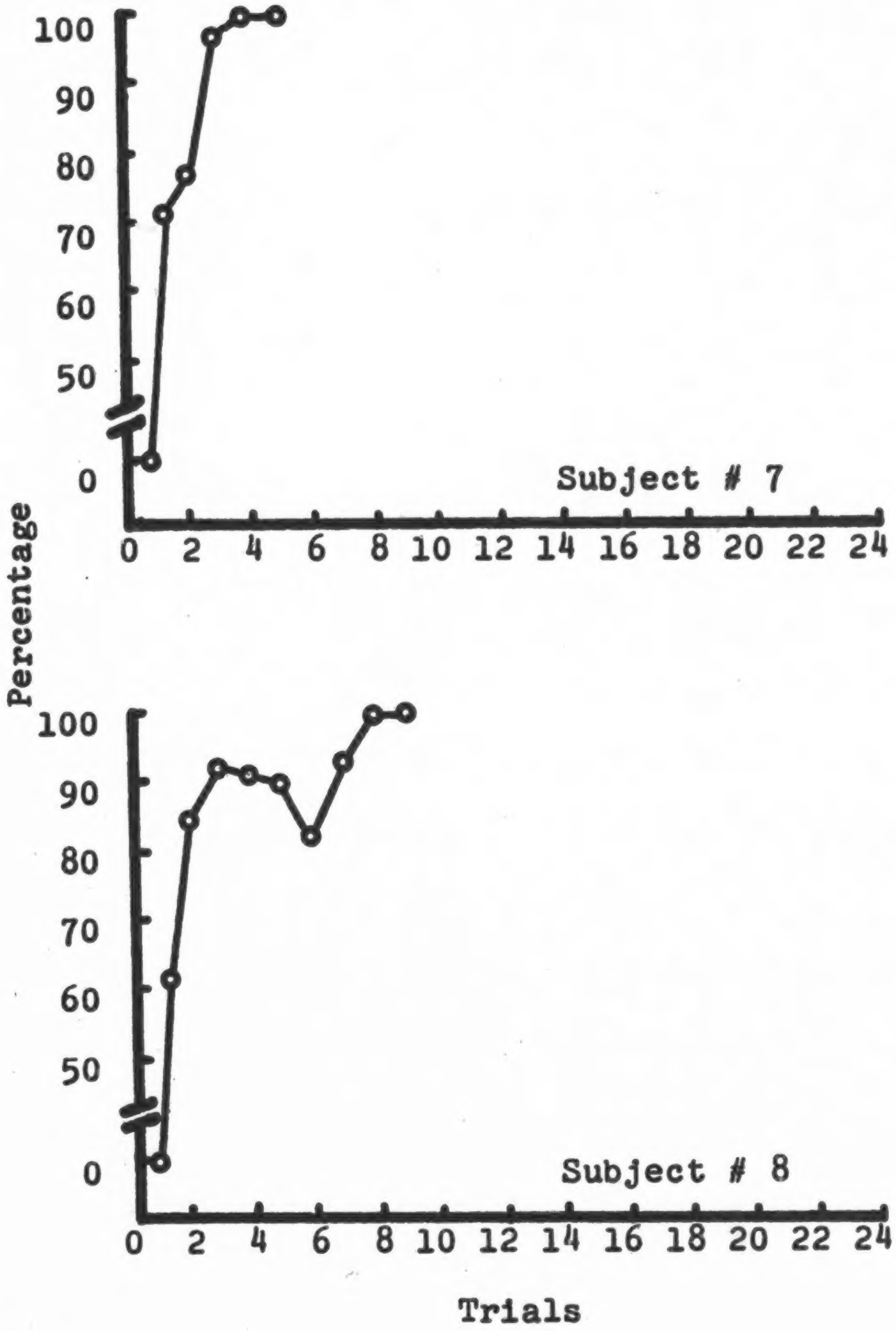
Subject # 6
0 2 4 6 8 10 12 14 16 18 20 22 24
Trials

FIGURE II d


100
90
80
70
60
50
0
Subject # 7
0 2 4 6 8 10 12 14 16 18 20 22 24
Percentage
100
90
80
70
60
50
0
Subject # 8
0 2 4 6 8 10 12 14 16 18 20 22 24
Trials

properties in order to maintain the chain, it would be expected that the acquisition curves for Task III would reflect a much less pronounced partial extinction effect than would those for Task I. Inspection of the graphs suggests that this is the case.

However, two additional hypotheses should also be considered in explanation of the differences in the number of trials to criterion: (1) that Task III is intrinsically "easier" with respect to behavioral demands and/or (2) characteristics of the stimulus configurations for Task III are such that the individual operants are more readily brought under the control of the respective stimulus components.

The first of these hypotheses appears untenable in view of the fact that a greater number of shaping trials were required for Task III, which would suggest that it was the more difficult of the two with respect to behavioral requirements. Non-experimental observations of the Ss during earlier training trials appeared to support this assumption.

This effect should have been confounded with the reinforcement such that, once the operants had been shaped and discriminated, the ensuing acquisition of criterion level would be augmented with perhaps a limiting of partial extinction. The acquisition patterns for subjects 5, 6, and 7 would appear to support this. For these Ss, then, it would appear as if the spacing of reinforcement hypothesis is more plausible than the task difficulty notion.

The third hypotheses is more difficult to interpret in terms of the data thus far presented, although it can be assumed that less effective discriminative stimuli would have been reflected in acquisition curves of more gradual slope. This concept of discrimination control will be treated in a later discussion of discrimination failure patterns.

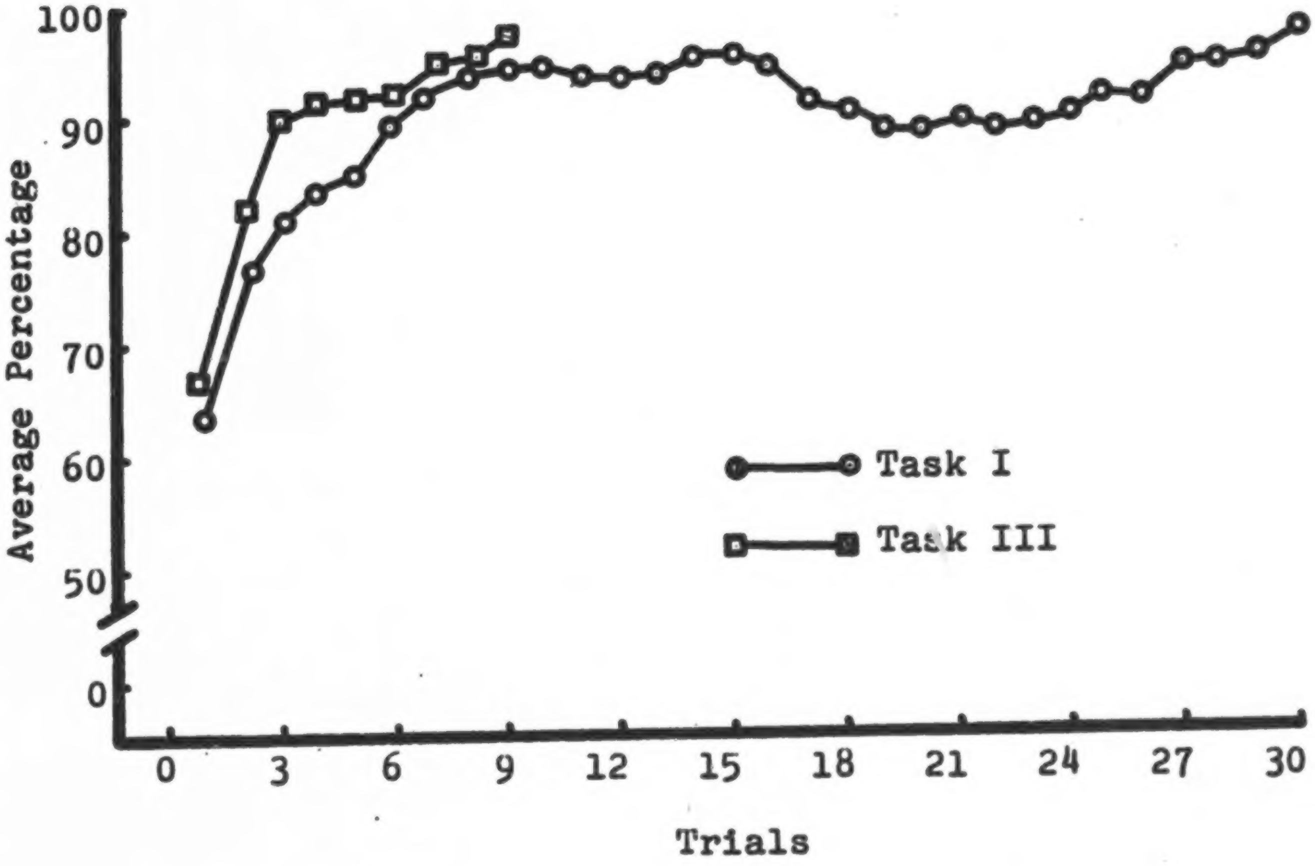
Placing the more technical consideration aside for the moment, Figure III gives a more general indication of the effectiveness of the experimental programs. The data presented here are based on group performance under the training conditions proper (excluding the zero point and the two criterion trials). The shape of the smoothed line graphs for the two tasks conforms roughly to a positively accelerated exponential curve, the classical pattern encountered in learning research (Ruch, 1958, p. 312).

These curves, of course, cannot be interpretated as directly reflecting response acquisition characteristics. Being based on the average percentages of discriminated operants for the group, they reflect somewhat less variation than is present in the actual performance. By the same token, the dip in the tail of the Task I curve is not indicative of actual response characteristics of the group, since the N upon which the percentages are based becomes smaller as the number of trials increase, and the right-hand segment of the curves thus reflects only the performance of

FIGURE III

Acquisition Patterns

Average Percentage of Discriminated Operants, on Successive Training Trails for Tasks I and III



the last S to achieve criterion. This effect is less noticeable in the curve for Task II, since there was less discrepancy in the number of Ss attaining criterion on the respective trials. The curves, however, are fairly representative of group performance through the tenth trial.

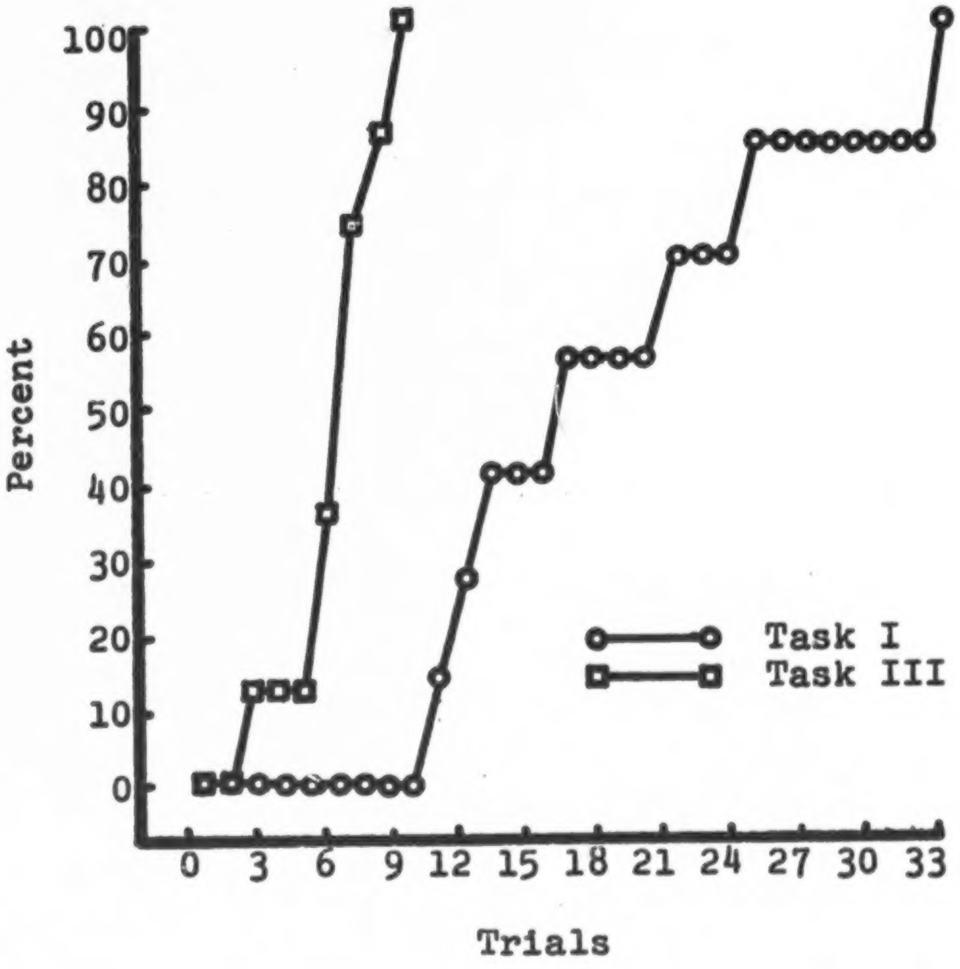
In similar fashion, Figure IV provides an indication of program efficiency. As the ogives demonstrate, 75% of the Ss had attained criterion by the sixth trial on Task III, whereas 21 trials had elapsed before a similar number of Ss had attained under Task I. This again gives indication of the relatively more rapid acquisition of criterion level of the assembly task and provides additional support for the contention that the spacing of reinforcement in the response chain directly effects programing efficiency.

Functions of the Component Stimuli and Program Efficiency

The stimulus components for the two tasks employed in this research served as discriminative stimuli for correlated responses, conditioned reinforcers for immediately preceding responses, and, in conjunction with experimenter-produced cues, as the "frames" in the instructional programs. The specification and selection of these stimuli is, therefore, a matter of critical significance to the acquisition and control of the specified behaviors. In view of this fact, an attempt was made to analyze the individual stimulus components for the two experimental tasks with respect to

FIGURE IV

Cumulative Percentages of S's Attaining Criterion by Trials: Tasks I and III



the question of their effectiveness in acquiring and maintaining discriminative control.

One of the difficulties in performing such an analysis involves forming a distinction between the role of the stimulus components as conditioned reinforcers and as discriminative stimuli. In the former case, failure to respond would be defined in terms of extinction, while reresponse failures under the latter condition would be a function of inadequate discriminative control.

It has been generally argued in the literature that the acquisition of stimulus discrimination for a given set of stimuli constitutes the necessary and sufficient conditions for the establishment of conditioned reinforcement effectiveness for those stimuli (Kelleher and Gollub, 1962). If this was solely the case, the conditioned reinforcement value of the component stimuli could be taken for granted. However, the "necessary and sufficient" hypothesis is not fully accepted on the basis of recent research findings. The evidence, in fact, is rather conflictual.

The present research, while not designed to provide an explicit test of this hypothesis, has yielded data which suggests that an effectively discriminated stimulus may not necessarily possess adequate reinforcement value. Specifically, it was observed that the rate of responses in the stimulus components, which were obviously efficient with respect to the acquisition of stimulus control, was somewhat dependent upon the spacing of primary reinforcement in the chain.

The use of experimental control procedures, such as replacing the chain schedule with a multiple or a tandem schedule (Kelleher and Gollub, 1962) to isolate the conditioned reinforcement effects, was not possible, since the nature of the experimental tasks precluded the necessary manipulations of the stimulus components. Another procedure, varying the discriminative value of the stimuli (in effect, revising the programs), would have been possible but was not attempted in the present research since a third, more practical approach was available. That is, data relevant to the patterns of response failures correlated with the individual stimuli, which was available as a result of the tabular method of recording responses, was used in an informal analysis of the relative effectiveness of the discriminative and reinforcement value of the respective stimuli.

Recalling from the discussion of Figures I and II, the initial peaks in the curves were taken as an indication of attainment of discriminative control. Since the acquisition of discriminative value must precede the formation of conditioned reinforcement properties, that segment of the curve which precedes the initial spike is considered an index of the discriminative efficiency of stimulus components, while the tail of the curve is assumed to reflect the formation of conditioned reinforcement. On this basis, a curve showing a very early spike followed by the rapid attainment of criterion level could be considered to reflect near optimal program efficiency. Several curves of this general configuration are present in Figure II. Conversely, curves showing a delayed spike and a delayed acquisition of criterion level would suggest an inefficient program. An example of this configuration is shown for Subject #1 in Figure Ia. A delayed spike is assumed to indicate deficits in discriminative control (assuming the correlated behaviors are available in the S's repertoire), while the delayed attainment of criterion level is assumed to reflect deficient reinforcement value for certain of the stimulus components.

It follows, then, that the patterns of response failures for the individual Task I operants based on the ratio of discriminated to nondiscriminated (experimenter-cued) operants emitted prior to the acquisition of discriminative control can be taken as an indication of the discriminative efficiency of the individual stimulus components (see Figure V). Similarly, Figure VI shows the patterns of response failures under the right-hand segment of the acquisition curve. The height of the ordinates of the graphs can be considered a rough estimate of the probability of a response failure occurring in the presence of the respective stimuli, assuming that the correlated response topographies are available in the subject's repertoire.

FIGURE V

Percentages of Response Failures for Early Trials: Task I

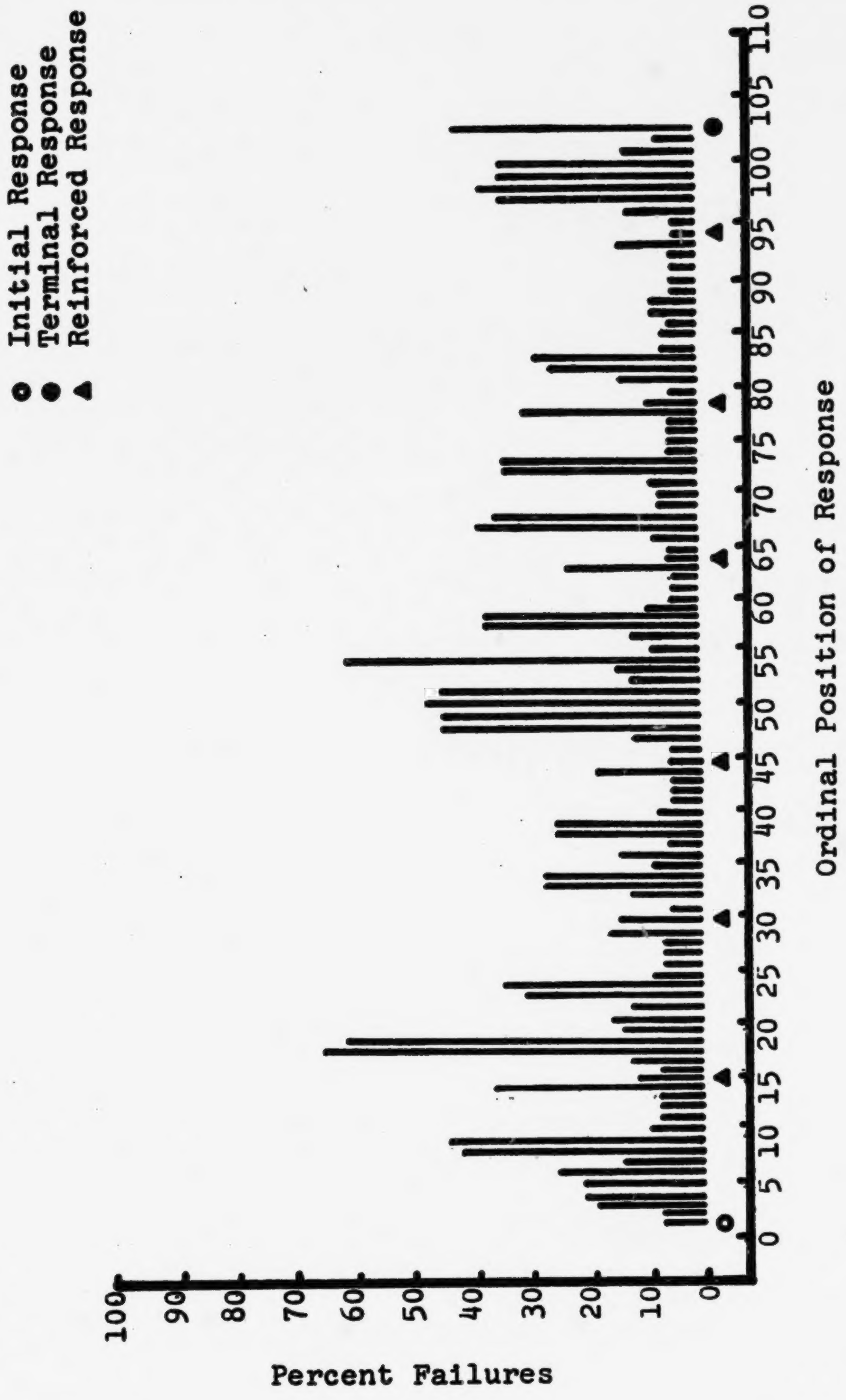
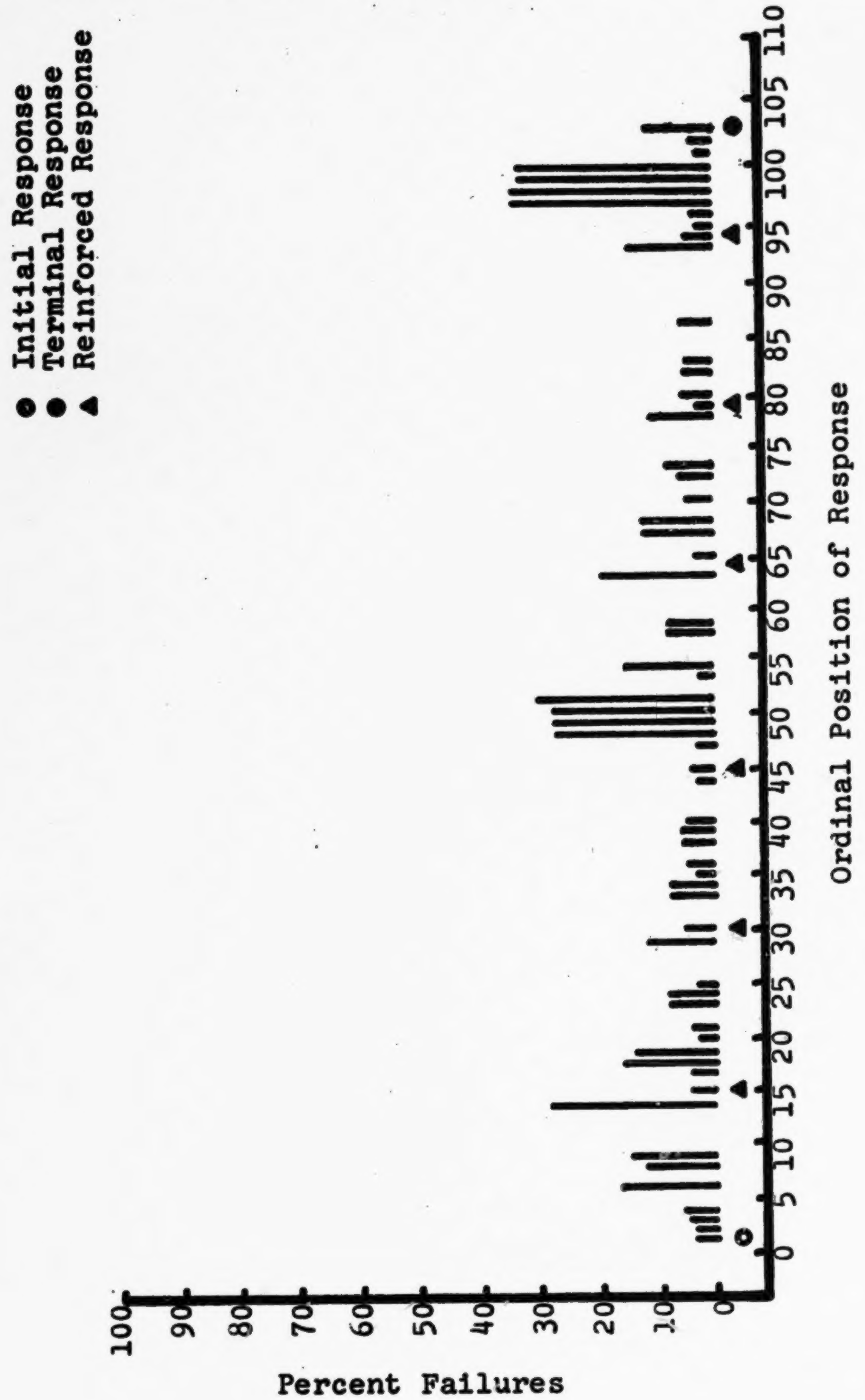


FIGURE VI

Percentages of Response Failures for Final Trials: Task I



The latter factor can be ascertained through direct observation of the S's behavior.

Examination of Figure VI shows that there is a general pattern of a greater percentage of response failures shortly following primary reinforcement (see Appendix A), with the error frequency diminishing as the next primary reinforcer is approached. This would suggest that the percentage of response failures is directly proportional to the proximity of the response (and the correlated stimuli) to primary reinforcement. Such an effect has been described as a common cause of response failures in a chain schedule, i.e., that the response rate in any of the component stimuli is due solely to the proximity of that component to primary reinforcement rather than to the conditioned reinforcing effect of the succeeding stimulus (Kelleher and Gollub, 1962). When this occurs, the entire chain would be essentially under the control of primary reinforcement, and the distributed effectiveness of the conditioned reinforcers would be of less significance than the spacing of primary reinforcers.

Figures VII and VIII show that this pattern is not explicitly duplicated for Task III, although again a higher percentage of response failures occur intermediate to, rather than at the point of reinforcement. This would seem to support the effect observed for Task I.

FIGURE VII

Percentages of Response Failures for Early Trials: Task III

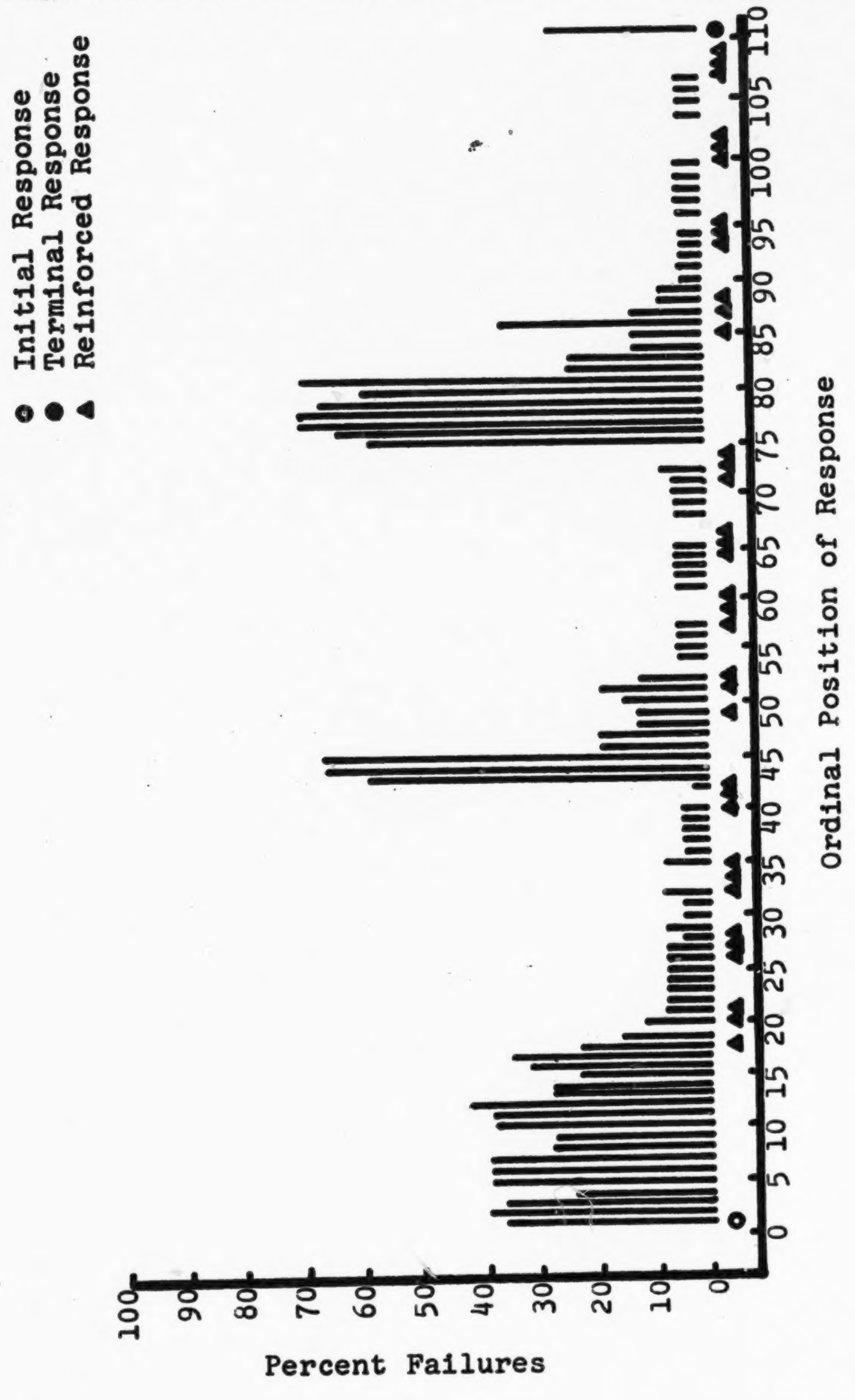
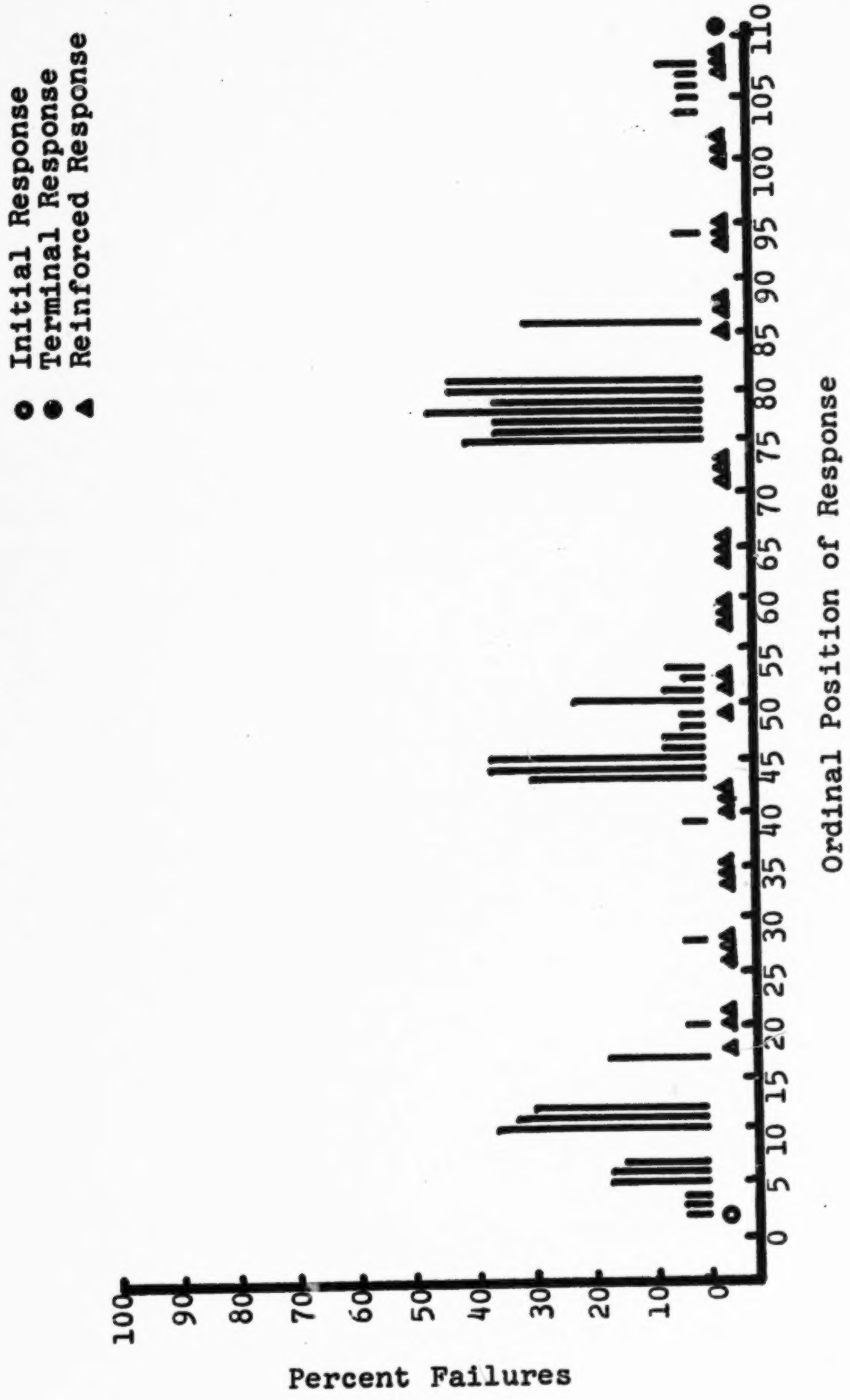


FIGURE VIII

Percentages of Response Failures for Final Trials: Task III



The evidence presented thus far would suggest that the spacing of primary reinforcers may be a critical element of program efficiency. However, comparison of Figures V with VI and VII with VIII suggests that, in general, response components having a higher percentage of failures following the attainment of 90% of acquisition were also among those having a higher error frequency during early acquisition. This would suggest that discriminative control over these responses may have been more difficult to establish, presumably, due to some characteristic of the correlated stimulus configuration.

Thus, it might be suspected that the discriminative efficiency of the individual stimulus components interacts with, or perhaps supercedes, the reinforcement effect. In effect, therefore, this analysis of response failure patterns tends to suggest an interaction between factors of discriminative efficiency and the spacing of primary reinforcers in the chain as the critical element contributing to program efficiency. The role of the component stimuli as conditioned reinforcers is not clearly defined by the data, but appears not to emerge as a separate critical function.

Retention

A question of some concern in any learning study has to do with the degree of retention which can be expected following an appreciable absence from the learning environment.

This would be particularly true in a workshop situation where work programs and production demands may vary considerably, and the workers may be expected to learn and perform a variety of tasks on demand. The seven S's for whom the original Task I data were obtained were re-introduced to the experimental environment under the performance (nonsupervised) conditions following a two month interval and data were collected in the manner described earlier. Table V depicts the percentage of the total Task I operants which were retained under the control of the correlated discriminative stimuli of the task. As can be seen from the data, retention for all subjects was very high for trial one, and perfect retention was spontaneously attained (without intervention or cuing by the experimenter) for all but one of the subjects on trial two. Formal retention studies were not performed for Tasks II and III; however, non-experimental observations produced evidence that the retention level for most of the S's was quite high on both tasks.

Comparisons of the Experimental and Control Groups

The third phase of the research was addressed to the question of whether operant conditioning priciples could be further extended to the maintenance of previously acquired vocational behaviors in the workshop environments. Recalling from Chapter III, two groups of subjects were randomly selected, one being assigned to an experimental

TABLE V

Percentage of Retention of Discriminated Task I Operants After Two Months

Subject	Percent Retention Trial 1	 Trial 2
1	100	100
2	98	100
3	99	99
4	98	100
5	99	100
6	99	100
7	98	100

condition wherein prescribed schedules of reinforcement were applied to their behaviors following pre-training on the vocational task, and the second (control) group rereceiving similar treatment with the exception that specifically scheduled extrinsic reinforcement was not employed.

In order to gain a broader sampling of the effects of reinforcement, three tasks were employed in this study: Task I and III from the preceding study, both of which were described as heterogeneous response chains, and the added Task II (described in Chapter III), which is technically defined in terms of a homogenous response chain.

Operant measures for Task I and III were based on "critical task operants," identified by asterisks in Appendices A and B. Operant measures for Task II were defined in terms of the total number of responses emitted during the experimental sessions. Since performance in Task II was typically characterized by relatively high response rates and thus constituted a difficult recording task, product-moment correlations were computed between the paired observations of two research assistants over 20 repeated observations as an index of inter-observer reliability (see Appendix J). The obtained $\underline{r}$ of .99 (significant beyond the .01 level) allows the assumption of relatively high reliability of the observations for this task. Tasks I and III were less demanding on the observers, and did not appear to warrant the computation of reliability estimates.

After pre-training on the three tasks (following the exact procedures defined for phase two of the research, excepting that social rather than food reinforcement was employed), the S's were run for ten consecutive 24 minute sessions in each of the experimental environments. Figure IX reflects the relative magnitude of the Task I operant measures over the ten sessions for both the experimental and control groups. As can be seen, the experimental group showed initially higher rates which were maintained over the remaining sessions. Both groups showed an obvious progressive trend with respect to the number of operants emitted as a function of sessions, which by inspection appears to conform to the linear model. Generally speaking, the trend appears to be quite similar for both groups. This is assumed to indicate the presence of a rather marked practice effect, which, for the control group, apparently had not reached an asymptotic level at the tenth day. The terminal data for the experimental group, however, suggests that the asymptote may have been approached.

Figure X reflects similar results with respect to Task II. Again, the data reflects a somewhat greater magnitude of response as a function of sessions for the experimental group. Likewise, the data reflects a trend, although in this case not explicily of a linear model. In contradistinction to the data presented for Task I, it appears as if both groups may have reached the asymptote on Task II.

FIGURE IX

Mean Critical Task Operants Emitted by
Experimental and Control Groups
as a Function of Replications:

Task I

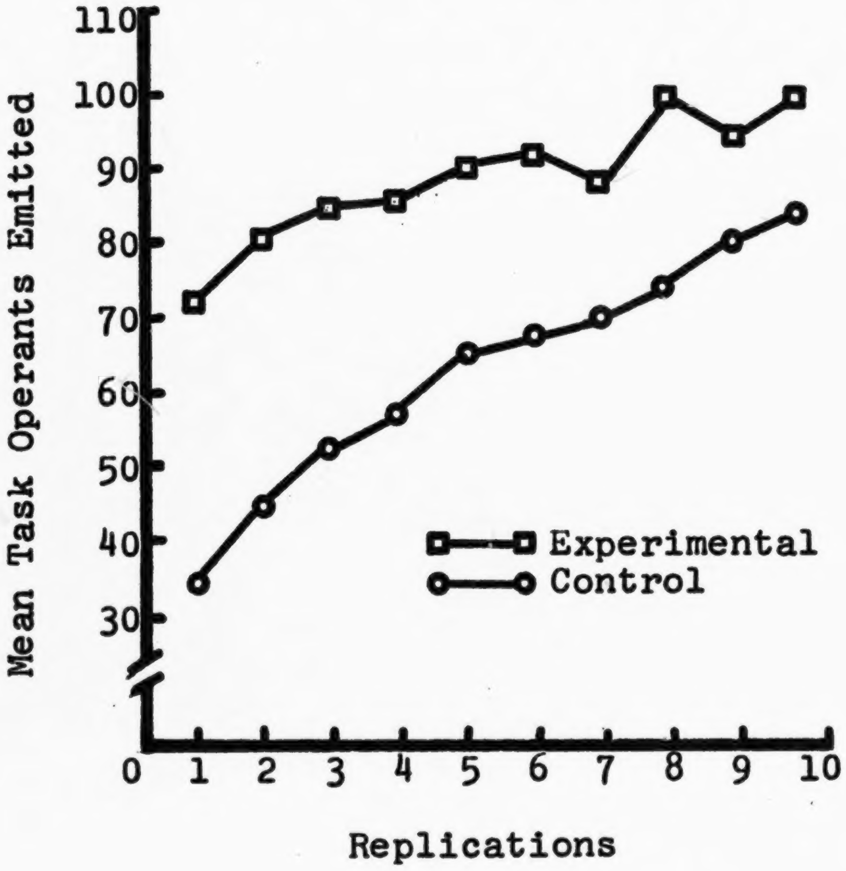


FIGURE X

Mean Critical Task Operants Emitted by
Experimental and Control Groups
as a Function of Replications:

Task II

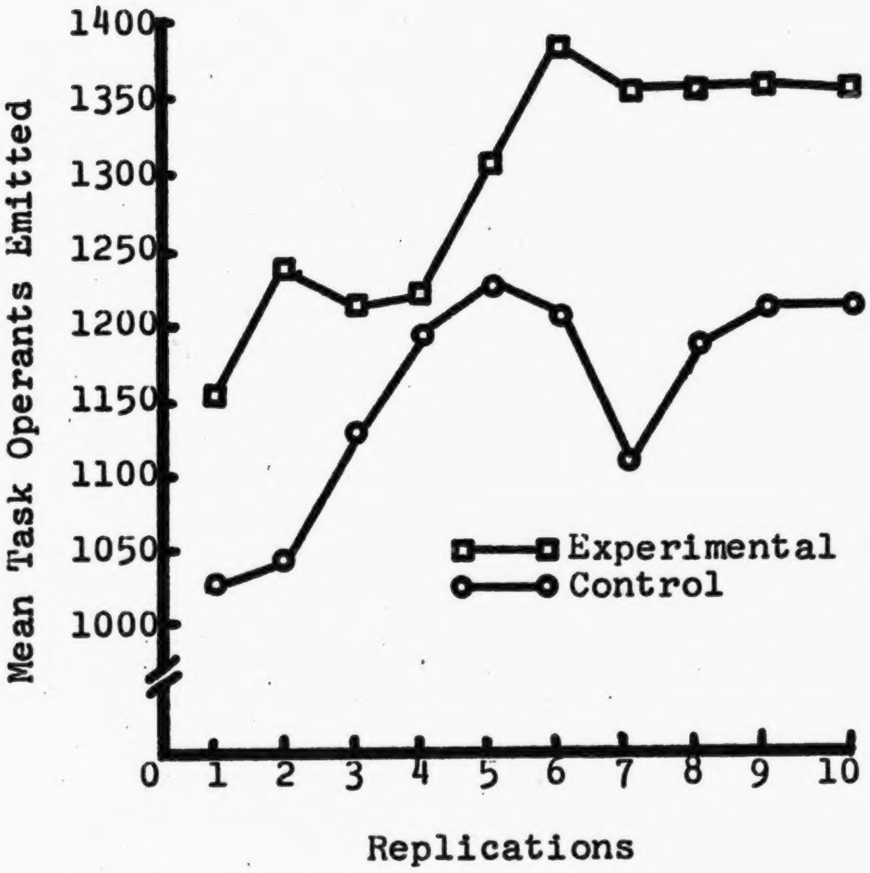


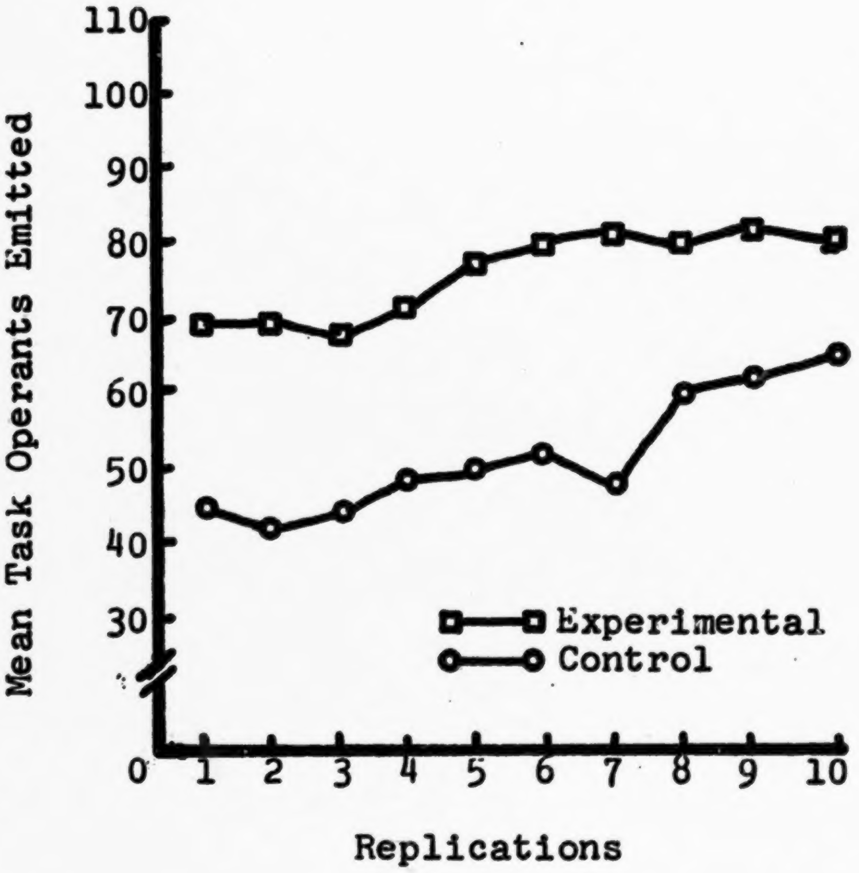
Figure XI presents similar data for Task III. As with Task I and II, the relative magnitude of response was again greater for the experimental group. Similarly, trends of a roughly linear nature were reflected for both groups, though of a lesser magnitude than those reflected in the preceding two line graphs. Also, as was suggested in the Task I data, it appears as if the control group had not reached an asymptote at the tenth trial, while the experimental group had apparently attained the asymptotic level by the sixth trial.

In comparing the three graphs, it appears as if the variability in the magnitude of response is relatively greater for both groups on Task II than for either Task I or III. The explanation for this is not explicitly clear in the available data, although it can be assumed this effect is somewhat related to the hypothesis derived from the data of the preceding section with respect to the influences of spacing of reinforcement on the behavior of the subjects. Task II, of course, being a homogenous chain under an FR 24 schedule, had the highest magnitude of spacing between extrinsic reinforcers of the three tasks. The hypothesis here would be that if the spacing had been reduced by substituting, for example, an FR 12 schedule, the variance in the experimental group measures might have been reduced.

FIGURE XI

Mean Critical Task Operants Emitted by
Experimental and Control Groups
as a Function of Replications:

Task III



It is interesting to note that the line graphs for the experimental group on Task II is essentially similar to the general configuration of the acquisition curves presented in the preceding sections. The hypothesis associated with this effect could be similar to that tendered for the effects under the training conditions, i.e., that the early reduction in response rate after an initial higher rate is a function of a partial extinction effect. This hypothesis appears quite plausible for this particular task, since, because a much lower ratio of reinforcement was employed under the procedures used to shape the subjects to the secondary reinforcers (tokens), the shift to an FR 24 schedule should produce approximately the same effect as a shift from a CRF to an FR schedule described earlier (Ferster and Skinner, 1957, p. 42). This effect should also have been present in a somewhat reduced magnitude for Task III, since a shift here was from a relatively low ratio to an FR 15. Inspection of the line graph for the experimental group on Task III suggests that this effect is borne out. The effect would not be expected to obtain under Task I, since the overall ratio of reinforcement for this task was relatively low. Again, examination of the appropriate graph suggests that the hypothesis is supported. Thus, it would appear as if vocational behaviors, as well as a variety of other behaviors observed in previous research, are sensitive to the effects of reinforcement procedures. On the other hand, inspection the line graphs for the control groups under the three task conditions suggests that nonscheduled social reinforcement is also effective in maintaing behaviors, although perhaps at somewhat lower rates. In a general sense, of course, the slightly lower rates might not be a significant concern in vocational applications, since the behaviors were obviously maintained under the social reinforcing conditions. This leaves many questions unanswered, however, such as the long term effects of social versus extrinsic reinforcement, which can only be ascertained by continued research of this type. Specifically, it would be quite interesting to determine whether both groups would have eventually attained similar asymptotic levels, and whether these asymptotes would have been maintained over considerable lengths of time. Of course, the effects of social reinforcement for this particular category of subject might be much more powerful than would be the case for higher level retardates, since the severely retarded generally are not programmed as extensively as higher level institution residents and thus may be relatively more deprived of social reinforcement. This is also a question for further research.

It was desirable, in this study, to specify criterion measures which would reflect the relative effects of control and experimental conditions in maintaining vocational behaviors. As previously noted, both groups under all task conditions showed a progressive trend over the ten sessions. Excepting the fact that the experimental group may have reached the asymptote earlier than the control group, these trends, however, appeared to be similar for both groups in all cases and thus were not considered a significant aspect of the analyses. In view of these facts, it was decided that criterion measures based on the average of the final two days of performance for the individual Ss would constitute adequate measures of behavior maintenance. The magnitude of the differences, of course, may have been depressed slightly at trial ten due to the earlier attainment of the asymptotic level by the experimental group, but since this would, in effect, reduce the risk of a Type I error, no adjustments were attempted. Tables VI, VII, and VIII give the total number of task operants emitted by sessions for both experimental and control groups as a function of tasks. As can be seen from the means and variances of the criterion measures for the three tasks, the assumption of unequal variances derived from inspection of the line graphs presented earlier is borne out in the actual data. This effect is partially due, of course, to the fact that the response measures for Task II are roughly of the order of ten times the magnitude of the measures for Task I and III. This, of course, indicates that the tasks cannot be considered equivalent with respect to scaling. In actuality, there is no basis

TABLE VI

Total Critical Task Operants Emitted by Experimental and Control Subjects in Final Two Sessions, and Rounded Averages: Task I

Experimental

S	Day 1	Day 2	Avg.
1	114	128	121
2	130	95	113
3	67	66	67
4	156	162	159
5	103	134	119
6	93	108	101
7	98	100	99
8	86	80	83
9	76	78	77
10	47	42	45
11	103	90	97
		ΣX	1081
		ΣX^2	115595
		$\bar{X}$	98.27
		s^2	937.15
		s	30.60

Control

S	Day 1	Day 2	Avg.
1	76	76	76
2	90	82	86
3	111	94	103
4	60	66	63
5	83	94	89
6	108	116	112
7	87	90	89
8	83	119	101
9	51	67	59
10	78	80	79
11	55	49	52
		ΣX	909
		ΣX^2	78763
		$\bar{X}$	82.64
		s^2	364.71
		s	19.10

TABLE VII

Total Critical Task Operants Emitted by Experimental and Control Subjects in Final Two Sessions, and Rounded Averages: Task II

Experimental

S	Day 1	Day 2	Avg.
1	1151	1164	1157
2	488	553	521
3	1150	1493	1322
4	2101	2103	2102
5	2335	2176	2256
6	2368	2048	2208
7	1221	1275	1248
8	1042	1013	1028
9	1070	1018	1044
10	923	956	940
11	1131	1135	1133
		ΣX	14959
		ΣX^2	23612491
		$\bar{X}$	1359.91
		S^2	326961.00
		S	571.80

Control

S	Day 1	Day 2	Avg.
1	1092	1143	1118
2	1841	1761	1801
3	1550	1389	1470
4	1821	2019	1920
5	1263	1187	1225
6	984	1156	1076
7	1489	1543	1516
8	1210	990	1100
9	757	833	795
10	588	606	597
11	833	791	812
		ΣX	13424
		ΣX^2	18142384
		$\bar{X}$	1220.36
		S^2	176022.00
		S	419.50

TABLE VIII

Total Critical Task Operants Emitted by
Experimental and Control Subjects in Final Two Sessions,
and Rounded Averages: Task III

Experimental

S	Day 1	Day 2	Avg.
1	106	108	107
2	104	102	103
3	54	60	57
4	108	90	99
5	90	91	91
6	81	72	77
7	111	108	110
8	63	61	62
9	76	79	78
10	72	69	71
11	46	56	51
		ΣX	906
		ΣX^2	78988
		$\bar{X}$	82.36
		S^2	436.65
		S	20.89

Control

S	Day 1	Day 2	Avg.
1	127	120	124
2	53	49	51
3	108	117	113
4	52	48	50
5	47	48	48
6	72	72	72
7	47	60	54
8	84	97	91
9	33	48	41
10	47	44	46
11	21	19	20
		ΣX	710
		ΣX^2	56128
		$\bar{X}$	64.54
		S^2	1030.07
		S	32.10

for assuming equivalence of the tasks on either a logical or a statistical basis, therefore, this need not be considered a critical effect, although this factor was considered in the specification of an experimental design.

A more important consideration is the obvious fact that the variances across the three tasks are grossly heterogeneous. Since it was desired to employ an analyses of variance design in the comparisons of the reinforcement effects, it was necessary to effect transformation of the data to attain more equivalent variances.

One approach to the choice of a transformation model can be based on a comparison of the proportionality of the sample means to the variances and standard deviations of the samples (Dixon and Massey, 1957, p. 183). If the means are approximately proportional to the variances of the respective samples, square root transformations are often appropriate. If, on the other hand, the means of the samples are proportional to the standard deviation of the respective samples, logrithmic transformations will often result in the variances being more nearly equal.

Table IX gives the proportional relationship of the sample means to their standard deviations and variances. As can be seen from the data, the means appear to be more nearly proportional to the sample standard deviations, thus the decision was made to effect logrithmic transformations of the individual measures. Tables X, XI, and XII show the

TABLE IX

Proportional Relationships of Sample Means to Standard Deviations and Variances

Experimental Group

	Task II	Task III	Task I
$\bar{X}$	100%	7.23%	6.06%
S	100%	5.35%	3.65%
S^2	100%	.28%	.13%

Control Group

	Task II	Task III	Task I
$\bar{X}$	100%	5.28%	6.77%
S	100%	7.65%	4.55%
S^2	100%	.58%	.20%

TABLE X

Logrithmic Transformations of Dependent Variable (Average of Operants Emitted in Final Two Sessions) for Experimental and Control Subjects: Task I

Experimental			Control		
S	Y	Y^1	S	Y	Y^1
1	121	4.79579	1	76	4.33073
2	113	4.72739	2	86	4.45435
3	67	4.20469	3	103	4.63473
4	159	5.06890	4	63	4.14313
5	119	4.77912	5	89	4.48864
6	101	4.60517	6	112	4.71850
7	99	4.59512	7	89	4.48864
8	83	4.41884	8	101	4.61512
9	77	4.34380	9	59	4.07754
10	45	3.80666	10	79	4.36945
11	97	4.57471	11	52	3.95124
	ΣX	49.92019		ΣX	48.27207
	ΣX^2	227.69706		ΣX^2	212.43278
	$\bar{X}$	4.53819		$\bar{X}$	4.38837
	S^2	.11492		S^2	.05970

TABLE XI

Logrithmic Transformations of Dependent Variable (Average of Operants Emitted in Final Two Sessions) for Experimental and Control Subjects: Task II

Experimental			Control		
S	Y	Y^1	S	Y	Y^1
1	1157	7.05186	1	1118	7.01930
2	521	6.25575	2	1801	7.49610
3	1322	7.18690	3	1470	7.29302
4	2102	7.65064	4	1920	7.56008
5	2256	7.72135	5	1225	7.11070
6	2208	7.69984	6	1070	6.97541
7	1248	7.12930	7	1516	7.32383
8	1028	6.93537	8	1110	7.00306
9	1044	6.95081	9	795	6.67834
10	940	6.84588	10	597	6.39192
11	1133	7.03262	11	812	6.69950
	ΣX	78.46032		ΣX	77.55126
	ΣX^2	561.51760		ΣX^2	548.04494
	$\bar{X}$	7.13275		$\bar{X}$	7.05011
	S^2	.18791		S^2	.12995

TABLE XII

Logrithmic Transformations of Dependent Variable (Average of Operants Emitted in Final Two Sessions) for Experimental and Control Subjects: Task III

Experimental			Control		
S	Y	Y^1	S	Y	Y^1
1	107	4.67283	1	124	4.82028
2	103	4.63473	2	51	3.93183
3	57	4.04305	3	113	4.72739
4	99	4.59511	4	50	3.91202
5	91	4.49981	5	48	3.87120
6	77	4.34380	6	72	4.27667
7	110	4.700448	7	54	3.98898
8	62	4.12713	8	91	4.51086
9	78	4.35671	9	41	3.71357
10	71	4.26268	10	46	3.82864
11	51	3.93183	11	20	2.99573
	ΣX	48.16816		ΣX	44.57717
	ΣX^2	211.63260		ΣX^2	183.30590
	$\bar{X}$	4.37892		$\bar{X}$	4.05247
	S^2	.07078		S^2	.26580

transformed data for the experimental and control S's, and the respective means and variances of the transformed data. As can be seen, the logrithmic transformations did have the effect of rendering the sample variances more nearly equal.

Using the transformed measures, a two-way analysis of covariance was undertaken, making use of a multiple linear regression program. The data were translated into Fortran statements and processed on the IBM 1620 computer available at the University of Oregon Statistical Laboratory. (For definitions of the experimental design, mathematical model, computer program, and data translation, see Appendices E through H.) The data were analyzed in four stages, the first being the main analysis of the combined data for both groups and all tasks including variables describing tasks and interaction effects. The remaining three passes constituted single-classification analyses for the three tasks independently excluding, of course, the task and interaction effects (see Appendix I).

Table XIII gives the regression coefficients, standard errors of regression, and t values from the main analysis. As can be seen, the t value for the second row (quadratic) effect is highly significant, which, since the t is in the negative direction and the V_2 variable is negative for Task II, would suggest that the means for Task II are significantly greater than those for Task I and II (see

TABLE XIII

Regression Coefficients, Standard Errors of Regression, and t Values from Main Analysis

Variable	Regression Coefficient	Standard Error	d.f.	t
Operants	5.283	.1497	58	35.271*
I.Q.	- .004	.0072	58	.556
Admission Age	.007	.0105	58	.667
Columns	.086	.0468	58	1.838*
Rows_1	- .1242	.0567	58	- 2.190*
Rows_2	- .9172	.0328	58	-27.963*
Interaction_1	.0176	.0655	58	.269
Interaction_2	.0521	.0655	58	.795[a]

---

*Significant at the .05 level of confidence.

[a] $p < .25$

Appendix E). The Row_1 (linear) effect is also significant, which, by the same method of analysis, would suggest that the Task I mean exceeds the mean for Task III. As previously indicated, the tasks are neither logically or statistically equatable, thus the task effects are of no particular interest in the analyses except for the fact that the magnitude of the variance contributed by the tasks effects largely accounts for the highly significant $\underline{t}$ obtained with respect to the overall means (based on the regression coefficient of the dependent [operant] measures). Thus, the overall mean effect is also of little value in the interpretations of the data.

The variables which were of greatest interest in the analyses are the columns and interactions effects. As can be seen, the column effect was significant, although to a lesser degree than the row effects. Noting that the $\underline{t}$ value for the column effect is in a positive direction, and that, from Appendix E, the U variable is positive for the experimental conditons, this would suggest that the overall effects of the experimental treatment was superior to that of the control condition.

The interaction effects were found to be nonsignificant. This is an interesting result in that the experimental design was arranged with three variables confounded across task conditions such that: (1) the schedules of reinforcement differed across tasks, as dictated by the intrinsic characteristics of the tasks themselves and a desire to provide a means of testing the relative effectiveness of reinforcement with respect to the spacing hypothesis derived from the phase two data, (2) the extrinsic characteristics of the task (e.g., stimulus configurations, response characteristics, physiological demands, etc.) were quite obviously different for each task, and (3) the assignment of an experimenter to a task environment remained constant throughout the experiment in order to avoid the difficulty of attempting to counterbalance experimenter effects.

Since the subjects were split between treatment conditions rather than tasks (see Appendix E), there existed the possibility that an interaction might have arisen as a result of contamination of Type S and G errors (Lindquist, 1956, p. 8).[1] The absence of significant interaction effects may, therefore, be taken as an indication both that the experiment was relatively efficient with respect to the control of extrinsic error and that the factor of the sensitivity of subject behavior under the various task conditions to reinforcement can be defined in terms of an orthogonal relationship. That is, it appears as if there are no incremental or decremental combinations of treatments and tasks.

---

[1] This design was chosen on the basis of economy and efficiency, i.e., complexities of instrumentation, and the overall duration of the experiment would have been greatly increased, and scheduling efficiency would have been decreased had the subjects been split between tasks rather than treatments. The risk in employing this design was a calculated one, since it was assumed that the covariance adjustments would tend to reduce the Type S errors, while the arrangement of the two interaction variables was such that interaction effects could be explicitly specified with regard to pattern, thus increasing the likelihood of differentiating between extrinsic and intrinsic interactions.

The absence of an intrinsic AB interaction is somewhat surprising, since the data obtained in phase two of the research suggested that there was a considerable discrepancy between the efficiency of the two chained schedules of reinforcement, which would be attributed to the spacing of the extrinsic reinforcers in the chain. That is, there appeared to be an inverse relationship between the magnitude of the temporal interval between reinforcers and the efficiency of the reinforcement schedules. This effect should have been generalizable to the phase three study.

More specifically, since the addition of Task II introduced an even greater discrepency with regard to the spacing of reinforcers, an intrinsic interaction was predicted between Task II (having the least efficient schedule) and Task III (which had the most efficient schedule) as a function of treatments. A re-examination of the data shows that, while a significant effect did not occur, there was a tendency toward significance in the second interaction variable. By referring to Appendices E and F, this effect can be traced to an interaction between the Task II control and Task III experimental conditions, a result which tends to support the prediction. Referring to Tables XI and XII, it can be seen that, for Task III, the experimental group reflects a larger mean and smaller variance in relation to the control group, while for Task II the means and variances for both samples are roughly equivalent. This would suggest that the reinforcement schedule employed for Task III tended to be more efficient than that employed for Task II, as was predicted.

Referring to Table VIII, it is shown that the Task III effect is transferable to the original data. Table VII shows that, for Task II, the effect is essentially inverted. That is, the means are roughly equivalent, but the variance for the control condition is considerably less than that observed for the experimental group. This would tend to further support the prediction and would suggest that the interaction effect might have been significant for the original data. Thus, the spacing of reinforcement continues to appear as a highly significant factor with respect to reinforcement effectiveness.

Table XIV gives the regression coefficients, standard errors, and $\underline{t}$ values for the single classification analyses of the separate tasks. The columns effects are of most interest here, since it is possible to determine more discretely which of the reinforcement schedules related

TABLE XIV

Regression Coefficients, Standard Errors of Regression, and t Values from Separate Experimental vrs. Control Group Analyses for Tasks I, II, and III

Variable	Regression Coefficient	Standard Error	d.f.	t
		Task I		
Operants	4.4567	.2149	18	20.780*
I.Q.	- .0011	.0104	18	.104
Admission Age	.00245	.0150	18	.163
Columns	- .07426	.0672	18	1.105[a]
		Task II		
Operants	7.2415	.2839	18	25.597*
I.Q.	- .0120	.0137	18	.876
Admission Age	.0132	.0198	18	.667
Columns	.0309	.0885	18	.349
		Task III		
Operants	4.1421	.2967	18	13.961*
I.Q.	.0007	.0143	18	.049
Admission Age	.0060	.0207	18	.290
Columns	.1604	.0928	18	1.728[b]

---

*Significant at the .05 level of confidence

[a]p <.15

[b]p <.10

to the respective tasks contributed more strongly to the significant treatments effect demonstrated in Table XIII. The t values show that, while none of the treatments are significant, the effect for Task III is nearly so ($t_{.05} = 1.734$) while the t obtained under Task I is also well above chance level. This, of course, indicates that the combination of the treatment effects for Tasks I and III contributed additively to the significant treatment effect obtained under the main analyses. The relative magnitude of the three t's shown in Table XIV also tends to support the hypothesis concerning the relative efficiency of the three reinforcement schedules.

Table XV gives the multiple correlation coefficients for the combined data, standard errors of the Y data, the standard error of the estimate, and the significance of the regression for both the main analysis and the separate analyses by tasks. These data must be interpreted with caution, due to the influences of the inordinately large row effects reflected in Table XIII. The multiple R and R^2, for example, are spuriously high because of this effect, and cannot be literally interpreted as reflecting the accuracy with which the concomitant variables are predicting the actual criterion measures or the amount of variance in the Y measures accounted for by the combination of the independent variables. Application of the Wherry skrinkage formula for removing chance error, however, gives

TABLE XV

Multiple Correlation Coefficients, Standard Errors of the Y Data, Standard Error of the Estimates, and Significance of the Regressions for the Main Analysis and Separate Analyses by Tasks

Statistic	Main Analysis	Task I	Task II	Task III
R	.9653	.2619	.2354	.3935
SE	1.3631	.2994	.3913	.4338
SE_{est}	.3765	.3121	.4108	.4308
F	113.3959	.4418	.3520	1.0994
R^2	.9318	.0686	.0554	.1549
R_c	.9610	-	-	-

assurance that the multiple R is relatively free of random variation (Garrett, 1964).

It is assumed that the coefficients obtained under separate, single classification analyses (computed without the rows and interaction variables) appeared to give a more reasonable estimate of the multiple R's. Likewise, the F test for the overall means effect under the main analysis is spuriously high, due to the same factors, while the overall means effects for the three tasks taken spearately are not significant.

Table XVI presents the intercorrelations of the independent variables employed in the main analysis. As was expected, the phi cofficients for the rows and interaction effects indicated the presence of an orthogonal relationship between the variables, with the exception of the non-orthogonality of the two interaction variables (I_1 and I_2) which occurred as an artifact of the arrangement of the interaction factor. Likewise, point-biserial coefficients between these variables and the covariates indicated the expected orthogonal relationship. The very small point-biserial coefficients observed between the treatment variable (U) and the two covariates suggest that neither I.Q. or admission age influence treatment effects. The observed product-moment correlation between I.Q. and admission age (significant at the .05 level) is consistant with the findings of previous research and is logically related to the

TABLE XVI

Intercorrelations of Independent Variables Employed in Main Analysis[1]

	I.Q.	A.A.	U	V_1	V_2	I_1	I_2
I_2	.00	.00	.00	.00	.00	.50	
I_1	.00	.00	.00	.00	.00		
V_2	.00	.00	.00	.00			
V_1	.00	.00	.00				
U	-.04	.09					
A.A.	.51*						
I.Q.							

---

[1] Refer to Appendix F for description of variables.

*Significant at the .05 level of confidence.

fact that the more severely retarded individuals are detected earlier and thus institutionalized earlier, while the relatively brighter individuals are maintained in the community until a later age (Windle, 1962).

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

Scope and Limitations of the Research

The research described in this report constitutes an exploratory effort to test the effectiveness of a set of scientific principles of behavior (Skinner, 1953) in application to the problem of vocational training for the mentally retarded. That is, the research activity was, in general, intended to generate experimental hypotheses, rather than to provide explicit tests of specific research questions. In view of this fact, while certain conclusions can be stated with a great deal of confidence, other inferences must be tempered with caution. The following comments are included as a guide for the interpretation of results.

First, the samples of severely retarded individuals employed in this research represent a fairly constricted subpopulation of the total class of individuals referred to as mentally retarded. Further, the use of institutionalized subjects further limits the generalizability of the research findings. While certain aspects of the current studies may be considered to hold implications for broader applications with less constricted samples, the specific results obtained are not intended to be generalized beyond the population estimated by the research samples. Secondly, while the subjects employed in this research were randomly selected from the population of available patients, there exists the possibility that the relatively small samples may have resulted in inaccuarate estimates of the parameters of the various statistics employed. For this reason, statistical results must be interpreted with caution.

Experimeter error constitutes another factor which must be considered in interpreting the data. While automatic programming and recording apparatus were employed to reduce, as much as possible, the error arising from this source, the data were in all cases collected with the assistance of experimenter-observers. In view of the fact that literally thousands of observations were taken for each of the research samples, it would be extremely unwise to discount the possible effects of human error in the obtainment of experimental data. However, these Type G errors were apparently relatively well controlled in the phase three experiment, or if present, were distributed orthogonally such that the critical analyses of treatment means were not adversely affected.

Other factors also arose during the course of the research which must be considered as additional sources of error. For example, occasionally a subject was not available during his assigned time for an experimental session due to illness, etc. Similarly, an experimental session was sometimes interrupted due to unavoidable circumstances. It must also be assumed that the subject's day to day performance was somewhat influenced by other factors external to the experimental environments. In addition to these factors, which would contribute to the within-subject error, a considerable range of differences between the performance levels of the individual subjects across tasks was observed, producing another source of variance. It is suspected that the extremely large differences observed between tasks in the phase three analyses is partly due to this source of variance.

Finally, a third set of factors arising within the experimental environments may have produced another source of error. For example, it was occasionally necessary to substitute materials which were unfamiliar to the subjects (e.g., a finishing nail substituted for a box nail). Also, on rare occasions a component of one of the jigs or training devices would malfunction, producing some variation in subject performance. In general, error originating from this source can be assumed to be randomly distributed and thus would be included in the random error term, which, judging from the overall estimate of experimental efficiency, was relatively small in the phase three experiment.

Some of the above mentioned factors may be considered of negligible importance as sources of errors, while others very likely produced an effect of greater magnitude. However, since this research was basically exploratory in nature and by implication one aspect of the experimental question involved the efficacy of the experimental design and procedures, the information obtained from these observations contributed to the results in terms of providing information relevant to essential requirements in future studies of this type. For example, since this research was geared to practical considerations and made use of techniques and facilities largely available in typical workshop settings, some loss of precision might have been predicted due to the use of relatively unsophisticated data collection methods. Thus, while the present research detected certain results which are potentially of critical concern to the total question of applying behavioral principles to natural environments, rigid tests of hypotheses derived from these results can only be accomplished through research employing more advanced experimental procedures and instrumentation.

Another factor germaine to the design of the phase three study involves the large between-subjects variance which is relatively common to operant research due to the discreteness and specificity of the measures employed.[1] For several reasons, within-subjects variability detected in operant research is also frequently high, although this is somewhat more dependent upon the types of behavior under study. In this research, within-subject's variability did not appear unduly large.

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[1] Personal communication with Dr. Joseph Spradlin, Parsons Research Project, Parsons, Kansas, August 1965.

Typically, treatments by subject's designs (Lindquist, 1956) or "own control" designs are employed to control these types of error. Such designs are highly appropriate when only one treatment condition is being examined, however, large order or sequence effects frequently become problematic where several conditions are examined simultaneously.

In the present research, the alternative approach of comparing treatments with respect to groups distributed across tasks was employed, permitting detection and adjustment of between-groups errors distributed across treatments. The within subject's errors, which are more difficult to interpret and control and are readily influenced by extraneous factors (Lindquist, 1956, p. 160), were distributed across the task conditions. This arrangement resulted in the more problematic within-subject error being limited to the less critical B factor, thus permitting more precise analysis of the treatments and interaction effects which were of primary concern. The chief disadvantage of this design was that it invalidated a test of the overall means effect which, in the case of the present research, was already logically implausable to the intrinsic differences between the tasks. Aside from this, both the experimental design and the mathematical model employed in the analyses appeared quite adequate and efficient in testing the experimental hypotheses.

The other sources of error arising from administrative problems and factors specific to the experimental environments are, of course, largely unavoidable in research of this type. The usual hope is that errors arising from these sources are randomly distributed, and unless contrary evidence emerges during the course of the experiment, this appears to be a reasonable assumption. One possible method of reducing this type of error in future experiments would be to limit the duration of the study or to employ longer sessions with fewer replications. This would also permit more adequate planning for the availability of supplies and materials, which constituted a rather troublesome problem in the present research.

Results, Conclusions, and Implications

The present research produced a number of results which, interpreted within the framework of the limitations cited above, have interesting implications for further applications of scientific principles of behavior to the area of vocational training for mentally retarded individuals. First of all, the initial research question was rather conclusively answered in the affirmative by virtue of the results obtained through phase one and two of the project. That is, vocationally naive, severely retarded males can be trained, using the prescribed procedures, to perform effectively in selected vocational environments.

More specifically, it can be asserted that principles of operant conditioning can be employed in a rather straightforward manner in the development of highly efficient programs of training for specific vocational skills. These applications were found to be facilitated through the use of task analysis techniques in specifying environmental (stimulus) components and behavioral requirements relevant to the task. Adaptations of techniques available for the development and refinement of instructional programs can then be employed to organize, sequence, and synthesize the training procedures (Silvern, 1963).

An interesting observation, and perhaps an important one which is not reflected in the data, is that the whole process of developing and writing the programs required very little time, relatively speaking, and that with only minimal training, nonprofessionals who were not familiar with behavior modification techniques were able to analyze a task and to specify and implement the appropriate training procedure with nearly 100% success on their initial attempt. This, of course, has rather interesting implication with respect to the possibilities of widespread application of these procedures. It is also a somewhat surprising fact, since the development of the more typical linear instructional program requires considerable investments of time and skill (Skinner, 1961, p. 170-171).

However, most of the previous research in programed instruction has related to the development of highly complex academic behaviors. On the other hand, the programs devised for the present research were based on the adaptations of programing principles and probably cannot be considered equivalent to the more complex procedures. Also, the terminal objectives for the vocational programs were relatively less complex and required fewer frames for their resolution. There is some evidence, incidentally, that behavior modification principles are being extended by nonprofessionals to other applications in natural environments with equally effective results.[2]

Another interesting incidental observation was that the exposure of the nonexperimental _S_'s to the nonprogramed task during the early phases of the research resulted in the subject's emmitting what can only be described as "stupid" behaviors, i.e., they appeared incapable of appropriated responses in the environments and persisted in responding to nearly every variety of stimuli except those correlated with the appropriate responses. This would lead one to suspect that Sarason (1959) should have included the subject's behavior patterns, as well as his developmental or intellectual quotient, as the explanatory basis for the paucity of research attempts with the severely retarded.

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[2] Lindsley, O.R. Material presented at the Seminar on Behavior Modification, University of Oregon, May 29, 1966.

Related to this is the additional observation that "stupid" behaviors were observed only fleetingly, if at all, in the subjects during their initial exposures to the experimental programs. In fact, under these structured conditions, the patient's behavior appeared quite inconsistent with expectations based on their level of retardation. An empirical result which is perhaps pertinent to this observation is the finding that I.Q. was uncorrelated with task behavior in the phase three research. Previous studies (Stolorow, 1961. p. 52) have consistently shown similar results.

The data from the phase two study also indicated that the acquisition of the response chains for the two experimental tasks occurred fairly rapidly for most subjects. This result, which was in contradiction to predictions based on pre-experimental estimates of task complexity, encouraged the research staff to attempt more challenging applications with a few of the phase two subjects following their involvement in the experiment. Nonexperimental observations of the subject's response to more complex training programs suggested that the principles could be readily extended to more demanding environments. For example, one subject learned several tasks, among which was the assembly of metal bands around the ends of the flower baskets. This required the acquisition of a very long, multi-stage response chain and would seem to imply that the experimental procedures may have validity for more complex applications, a hypotheses which most certainly should be explored in further research.

With regard to the tasks studied in the present research, task difficulty or complexity with respect to behavioral demands did not appear to function as a critical factor influencing either acquisition rates or retention. Rather, the phase two data appeared to indicate that the discriminative value of the stimulus components associated with the respective responses, together with the spacing of extrinsic reinforcers in the response chain, constituted the only two factors which were critically related to subject performance. In another manner of speaking, these two factors appeared to be the primary determinates of program efficiency.

This is perhaps one of the more significant findings of the phase two study and has two general implications. First, the results would suggest that future attempts at developing programs of this type should include careful considerations of the specifications of stimulus components and reinforcement schedules. Secondly, it implies that the degree of complexity of behavior chains which can be conditioned is dependent upon the capability of performing adequate analyses of environments and of prescribing discrete consequential events.

The significance of these hypotheses to the overall problem of vocational training for the mentally retarded would seem to warrant further research along these lines. Similarly, the surprising discovery that the Ss were able to perform at least one of the tasks with almost perfect rentention following a two month interval with no exposure to the experimental environments provides many implications for further research.

Phase three of the research provided a means of testing the hypothesis that there would be no differences between the effectiveness of extrinsic, scheduled reinforcers and nonscheduled social reinforcement with respect to the maintenance of vocational behaviors in prescribed task environments. A multiple covariance analysis yielded an omnibus test across two treatment conditions and three experimental tasks.

For the experimental group, behaviors under each of the experimental environments were reinforced under grossly different schedules of reinforcement, each of which, however, was selected to increase the probability of attaining high and stable rates of behavior. Results of the analysis suggested that scheduled extrinsic reinforcement is at least slightly superior to typical reinforcement procedures in vocational environments.

Single classification analyses of each task across the two treatments indicated that the superiority of the extrinsic reinforcement was slight and manifest most strongly in Task III. A weaker effect was observed for Task I, while the control versus experimental differential was nonexistent for Task II. This result seems to add support to the previous discussion concerning a significance of the spacing of extrinsic reinforcers in the determination of the efficiency of the behavioral application.

The implications here are twofold. First of all, while the value of the application of behavioral principles to the training of vocational behaviors among retardates appears to be fairly well demonstrated, less value might be ascribed to extension of these principles to the problem of maintaining behaviors once they have been acquired. This possibility, which is in opposition to the general conclusions of previous operant research should most assuredly be subjected to further, more rigorous study. Secondly, the effect that was obtained might have been a function of the types of schedules of extrinsic reinforcement which were employed. Recalling from earlier discussions, for example, one factor which seemed to present itself repeatedly was related to the notion that the spacing of the extrinsic reinforcers in a response chain was critically related to program efficiency.

If this notion could be generalized to the concept of behavior maintenance, as well as training, and in particular to the preswnt experiment, an interaction effect between treatments and tasks would have been expected. Again, the result was nonsignificant although a recognizable tendency toward the effect was present. Specifically, it was suggested that the relative effectiveness of the two treatment conditions was the greatest for the experimental group in Task III and the control group in Task II. This observation was supported to some degree through further inspection of the data. Again, additional research should be designed to explore this question more thoroughly. If it can be decisively demonstrated that carefully programed reinforcement is distinctly superior to other methods of maintaining behaviors, perhaps one should look to innovations in a variety of training areas.

As a final point of discussion, it is interesting to note that, while the present research was not designed to permit highly discrete observations of behavioral patterns; nevertheless, there are several indications of relationships between behavioral patterns observed under the experimental conditions of the present research and those which might have been predicted on the basis of previous operant research with human and infra-human subjects. For example, data for Task I under phase two of the research clearly evidenced the presence of a partial extinction effect following a shift from a continuous to an intermitant reinforcement schedule. This effect has been repeatedly demonstrated in previous operant research and is considered to be a basic characteristic of fixed ratio of reinforcement (Ferster and Skinner, 1957).

Another result of the present research relates to the traditional hypothesis that the establishment of discriminative control for a particular stimulus constitutes the necessary and sufficient condition for that stimulus to function as a conditioned reinforcer. This hypothesis is, in turn, related to the assumption that a response chain is maintained on the basis of the conditioned reinforcing properties of the individual stimulus components. Results of the present studies suggested that the role of the stimuli as conditioned reinforcers was an unimportant consideration and that the response chains were more explicitly under the control of extrinsic reinforcement. These results, while not conclusive with respect to the present research, are somewhat similar to results of recent research on the role of conditioned reinforcement in the acquisition and maintenance of chained behaviors (Kelleher and Gollub, 1962).

A third result of some interest is that the acquisition patterns under the two experimental tasks studied in phase one of the research could be described in terms of an exponential function similar to that which defines the generic "learning curve." Thus, it might be reasonable to hypothesize that vocational behaviors conform to general behavior laws.

Due to the exploratory nature of the present research and the resulting limitations, each of the above observations must be considered as basically only indicative or suggestive of the effects they describe. On this basis, perhaps the most valid conclusions which can be drawn from the data are: (1) pragmatically speaking, the research model appears to "work" and (2) on this basis, further research is clearly warranted.

Summary

Working from a population of vocationally naive, severe-retarded residential school patients, an attempt was made to program subjects on selected workshop tasks. Task analysis was employed to describe the respective vocational environments and to specify behavioral components. Training programs based upon principles of shaping, operant discrimination, and chaining of responses were then developed around these behavior topographies.

An experimental design was developed to permit empirical tests of (1) whether randomly selected subjects could be trained by use of these procedures to function effectively in the prescribed vocational settings, (2) the comparative efficiency of different combinations of reinforcement procedures and task conditions in maintaining acquired behaviors, and (3) whether behavioral predictions based on previous operant research are valid in the prescribed settings.

A preliminary study was conducted in order to determine the response acquisition characteristics of a random sample of ten severely retarded individuals. These subjects, ranging in age from 18 through 30 years were systematically exposed to two experimental task environments. Both tasks involved, as terminal objectives, the acquisition of a complex chain of over 100 discrete response topographies . The resulting data showed that response acquisition characteristics were reflected in positively accelerated exponential curves.

In order to further evaluate the effectiveness of operant conditioning in application to vocational environments, a second study was designed to test the effects of reinforcement schedules upon the maintenance of previously acquired behaviors. Twenty-two subjects were randomly assigned to control and experimental groups. The age, I.Q., and admission age distributions for these groups did not differ significantly from the phase two group.

Both groups were trained on the two experimental tasks employed in the phase two group. Additionally, both groups were shaped to perform a sanding operation which involved the monotonous repetition of a single response topography. Both groups were then exposed to the experimental tasks for a series of ten daily, 24 minute "work" sessions.

The control group was maintained on relatively low, but constant levels of social reinforcement (consistent with typical workshop environments), while the experimental group was placed under the control of token reinforcement schedules maximizing the probability of obtaining high and stable response rates. Using mean operant rates for the final two days of performance as the dependent variable, a two-way analysis of variance was performed.

Although the control condition of social reinforcement was also shown to maintain the behavior at adequate levels, the results suggest that scheduled token reinforcement maintains higher and more stable rates of vocational behavior than nonscheduled reinforcement.

In terms of future applications of these precedures, the data suggested that the discriminative efficiency of stimulus components and the spacing of extrinsic reinforcers critically influence program efficiency.

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APPENDIX A

TAXONOMY OF THE TASK I TOPOGRAPHIES

Ordinal Positions	Response Topographies
1	Assume position facing drill press.
2	Adjust position, moving right shoulder in line with drill.
3	Extend left hand to stack of precut blanks.
4	Remove blank from stack.
5	Transfer blank to drilling jig.
6	Align and position in alignment block well (black).
7	Remove left hand; close 2nd, 3rd, and 4th fingers against palm.
8	With palm down, place exposed surface of 2nd finger against lower edge of blank.
9	Place thumb against near edge, index finger against far edge of blank; grasp firmly.
10	Extend right hand to drill press lever.
11	Open and lift hand, palm facing lever.
12	Extend thumb, forming V with index finger.
13	Bring palm in contact with tip of lever with shaft intersecting V.
14	Slowly rotate forearm downward (minimum interval 5 sec.) allowing shaft to rotate through V.
*15	At point lever ceases to rotate, extend forearm directly toward rear of machine, allowing lever to rest at base of thumb.
16	At point lever ceases to rotate, release and allow to return to initial position.
17	Remove left hand from blank.

18 Place tip of right index finger against upper edge of red spacer.
19 Lift and remove spacer.
20 Extend fingers of left hand; close 2nd, 3rd, and 4th fingers against palm.
21 Pull alignment block as far as possible toward body.
22 Remove left hand; close 2nd, 3rd, and 4th fingers against palm.
23 With palm down, place exposed surface of 2nd finger against lower edge of blank.
24 Place thumb against near edge, index finger against far edge of blank; grasp firmly.
25 Extend right hand to drill press lever.
26 Open and lift hand, palm facing lever.
27 Extend thumb, forming V with index finger.
28 Bring palm in contact with tip of lever with shaft intersecting V.
29 *Slowly* rotate forearm downward (minimum interval 5 sec.) allowing shaft to rotate through V.
*30 At point lever ceases to rotate, extend forearm directly toward rear of machine, allowing lever to rest at the base of the thumb.
31 At point lever ceases to rotate, release and allow to return to initial position.
32 Remove left hand from blank.
33 Place tip of right index finger against upper edge of *yellow* spacer.
34 Lift and remove spacer.
35 Extend fingers of left hand to touch far edge of alignment block (white).
36 Pull alignment block as far as possible toward body.
37 Remove left hand; close 2nd, 3rd, and 4th fingers against palm.
38 With palm down, place exposed surface of 2nd finger against lower edge of blank; grasp firmly.
39 Place thumb against near edge, index finger against far edge of blank; grasp firmly.
40 Extend right hand to drill press lever.
41 Open and lift hand, palm facing lever.
42 Extend thumb, forming V with index finger.
43 Bring palm in contact with tip of lever with shaft intersecting V.
44 *Slowly* rotate forearm downward (minimum interval 5 sec.) allowing shaft to rotate through V.
*45 At point lever ceases to rotate, extend forearm directly toward rear of machine, allowing lever to rest at the base of the thumb.
46 At point lever ceases to rotate, release and allow to return to initial position.
47 Do *not* release blank; slide alignment block (white) toward far edge of jig base (blue).
48 Extend right hand; grasp red spacer.

49 Transfer to jig base (blue); position over corresponding red strip.
50 Remove right hand, extend to grasp yellow spacer.
51 Transfer to jig base (blue); position over corresponding yellow strip.
52 Remove right hand.
53 Do not release blank, slide alignment block (white) as far as possible toward body.
54 Turn block around to opposite side.
55 Align and position in alignment block well (black).
56 Remove left hand; close 2nd, 3rd, and 4th fingers against palm.
57 With palm down, place exposed surface of 2nd finger against lower edge of blank.
58 Place thumb against near edge, index finger against far edge of blank; grasp firmly.
59 Extend right hand to drill press lever.
60 Open and lift hand, palm facing lever.
61 Extend thumb, forming V with index finger.
62 Bring palm in contact with tip of lever with shaft intersecting V.
63 Slowly rotate forearm downward (minimum interval 5 sec.) allowing shaft to rotate through V.
*64 At point lever ceases to rotate, extend forearm directly toward rear of machine, allowing lever to rest at the base of the thumb.
65 At point lever ceases to rotate, release and allow to return to initial position.
66 Remove left hand from blank.
67 Place tip of right index finger against upper edge of red spacer.
68 Lift and remove spacer.
69 Extend fingers of left hand; close 2nd, 3rd, and 4th fingers against palm.
70 Pull alignment block as far as possible toward body.
71 Remove left hand; close 2nd, 3rd, and 4th fingers against palm.
72 With palm down, place exposed surface of 2nd finger against lower edge of blank.
73 Place thumb against near edge, index finger against far edge of blank; grasp firmly.
74 Extend right hand to drill press lever.
75 Open and lift hand, palm facing lever.
76 Extend thumb, forming V with index finger.
77 Bring palm in contact with tip of lever with shaft intersecting V.
78 Slowly rotate forearm downward (minimum interval 5 sec.) allowing shaft to rotate through V.
*79 At point lever ceases to rotate, extend forearm directly toward rear of machine, allowing lever to rest at the base of the thumb.

80 At point lever ceases to rotate, release and allow to return to initial position.
81 Remove left hand from blank.
82 Place tip of right index finger against upper edge of yellow spacer.
83 Lift and remove spacer.
84 Extend fingers of left hand to touch far edge of alignment block (white).
85 Pull alignment block as far as possible toward body.
86 Remove left hand; close 2nd, 3rd, and 4th fingers against palm.
87 With palm down, place exposed surface of 2nd finger against lower edge of blank.
88 Place thumb against near edge, index finger against far edge of blank; grasp firmly.
89 Extend right hand to drill press lever.
90 Open and lift hand, palm facing lever.
91 Extend thumb, forming V with index finger.
92 Bring palm in contact with tip of lever with shaft intersecting V.
93 Slowly rotate forearm downward (minimum interval 5 sec.) allowing shaft to rotate through V.
*94 At point lever ceases to rotate, extend forearm directly toward rear of machine, allowing lever to rest at the base of the thumb.
95 At point lever ceases to rotate, release and allow to return to initial position.
96 Do not release blank; slide alignment block (white) toward far edge of jig base (blue).
97 Extend right hand; grasp red spacer.
98 Transfer to jig base (blue); position over corresponding red strip.
99 Remove right hand; extend to grasp yellow spacer.
100 Transfer to jig base (blue); position over corresponding yellow strip.
101 Remove right hand.
102 Do not release blank; slide alignment block (white) as far as possible toward body.
103 Remove blank from jig; transfer to storage.

APPENDIX B

TAXOMONY OF THE TASK III TOPOGRAPHIES

Ordinal Positions	Response Topographies
1	Assume position facing jig.
2	Extend right hand to red spacer; transfer to jig.
3	Insert red spacer and position in jig frame.
4	Remove basket end from stack.
5	Transfer to position above right side of frame.
6	Insert at angle corresponding to white strip.
7	Push basket end against frame bottom.
8	Rotate basket end, abutting yellow guide.
9	Remove basket end from stack.
10	Transfer to position above left side of frame.
11	Insert at angle corresponding to white strip.
12	Push basket end, abutting yellow guide.
13	Rotate basket end, abutting yellow guide.
14	Extending right hand, remove slat from stack.
15	Transfer slat to postion above frame.
16	Rest tips of slats against tops of basket ends.
17	Extend left hand palm up below slat; grasp slat.
*18	Slide slat toward body, abutting both yellow guides.
19	Extend right hand; grasp hammer.
20	Drive right nail flush with slat surface.
*21	Drive left nail flush with slat surface.
22	Extending right hand, remove slat from stack.
23	Transfer slat to position above frame.
24	Rest tips of slats against tops of basket ends.
25	Extend left hand palm up below slat; grasp slat.
*26	Slide slat toward body, abutting previously installed slat.

*27 Drive right nail flush with slat surface.
*28 Drive left nail flush with slat surface.
29 Extending right hand, remove slat from stack.
30 Transfer slat to position above frame.
31 Rest tips of slats against tops of basket ends.
32 Extend left hand palm up below slat; grasp slat.
*33 Slide slat toward body, abutting previously installed slat.
*34 Drive right nail flush with slat surface.
*35 Drive left nail flush with slat surface.
36 Extending right hand, remove slat from stack.
37 Transfer slat to position above frame.
38 Rest tips of slats against tops of basket ends.
39 Extend left hand palm up below slat; grasp slat.
*40 Slide slat toward body, abutting previously installed slat.
*41 Drive right nail flush with slat surface.
*42 Drive left nail flush with slat surface.
43 Grasp both ends of assembly.
44 Rotate assembly forward, abutting slats to blue support and basket ends to yellow guides.
45 Extending right hand, remove slat from stack.
46 Transfer slat to position above frame.
47 Rest tips of slats against top of basket ends.
48 Extend left hand palm up below slat; grasp slat.
*49 Slide slat toward body, abutting both yellow guides.
50 Extending right hand, grasp hammer.
*51 Drive right nail flush with slat surface.
*52 Drive left nail flush with slat surface.
53 Extending right hand, remove slat from stack.
54 Transfer slat to position above frame.
55 Rest tips of slats against top of basket ends.
56 Extend left hand palm up below slat; grasp slat.
*57 Slide slat toward body, abutting previously installed slat.
*58 Drive right nail flush with slat surface.
*59 Drive left nail flush with slat surface.
60 Extending right hand, remove slat from stack.
61 Transfer slat to position above frame.
62 Rest tips of slats against tops of basket ends.
63 Extend left hand palm up below slat; grasp slat.
*64 Slide slat toward body, abutting previously installed slat.
*65 Drive right nail flush with slat surface.
*66 Drive left nail flush with slat surface.
67 Extending right hand, remove slat from stack.
68 Transfer slat to position above frame.
69 Rest tips of slats against tops of basket ends.
70 Extend left hand palm up below slat; grasp slat.
*71 Slide slat toward body, abutting previously installed slat.

*72 Drive right nail flush with slat surface.
*73 Drive left nail flush with slat surface.
74 Grasp red spacer beneath installed slats with both hands.
75 Lift up and away from body, removing assembly from frame.
76 Invert assembly (bottom of red spacer up), set on table.
77 Remove and set aside red spacer.
78 Grasp inverted right basket end with left hand, left basket end with right hand.
79 Rotate hands, reversing position of basket ends.
80 Push entire assembly toward bottom of frame, abutting basket top firmly against yellow guides, bottom against blue support.
81 Extending right hand, remove slat from stack.
82 Transfer slat to position above frame.
83 Rest tips of slats against top of basket ends.
84 Extend left hand palm up below slat; grasp slat.
*85 Slide slat toward body, abutting both yellow guides.
86 Extending hand, grasp hammer.
*87 Drive right nail flush with slat surface.
*88 Drive left nail flush with slat surface.
89 Extending right hand, remove slat from stack.
90 Transfer slat to position above frame.
91 Rest tips of slats against tops of basket ends.
92 Extend left hand palm up below slat; grasp slat.
*93 Slide slat toward body, abutting previously installed slat.
*94 Drive right nail flush with slat surface.
*95 Drive left nail flush with slat surface.
96 Extending right hand, remove slat from stack.
97 Transfer slat to position above frame.
98 Rest tips of slats against tops of basket ends.
99 Extend left hand palm up below slat; grasp slat.
*100 Slide slat toward body, abutting previously installed slat.
*101 Drive right nail flush with slat surface.
*102 Drive left nail flush with slat surface.
103 Extending right hand, remove slat from stack.
104 Transfer slat to position above frame.
105 Rest tips of slats against tops of basket ends.
106 Extend left hand palm up below slat; grasp slat.
*107 Slide slat toward body, abutting previously installed slat.
*108 Drive right nail flush with slat surface.
*109 Drive left nail flush with slat surface.
110 Grasp across slats near basket ends, lift assembly up and toward rear of frame.
111 Remove assembly from frame, transfer to storage.

APPENDIX C

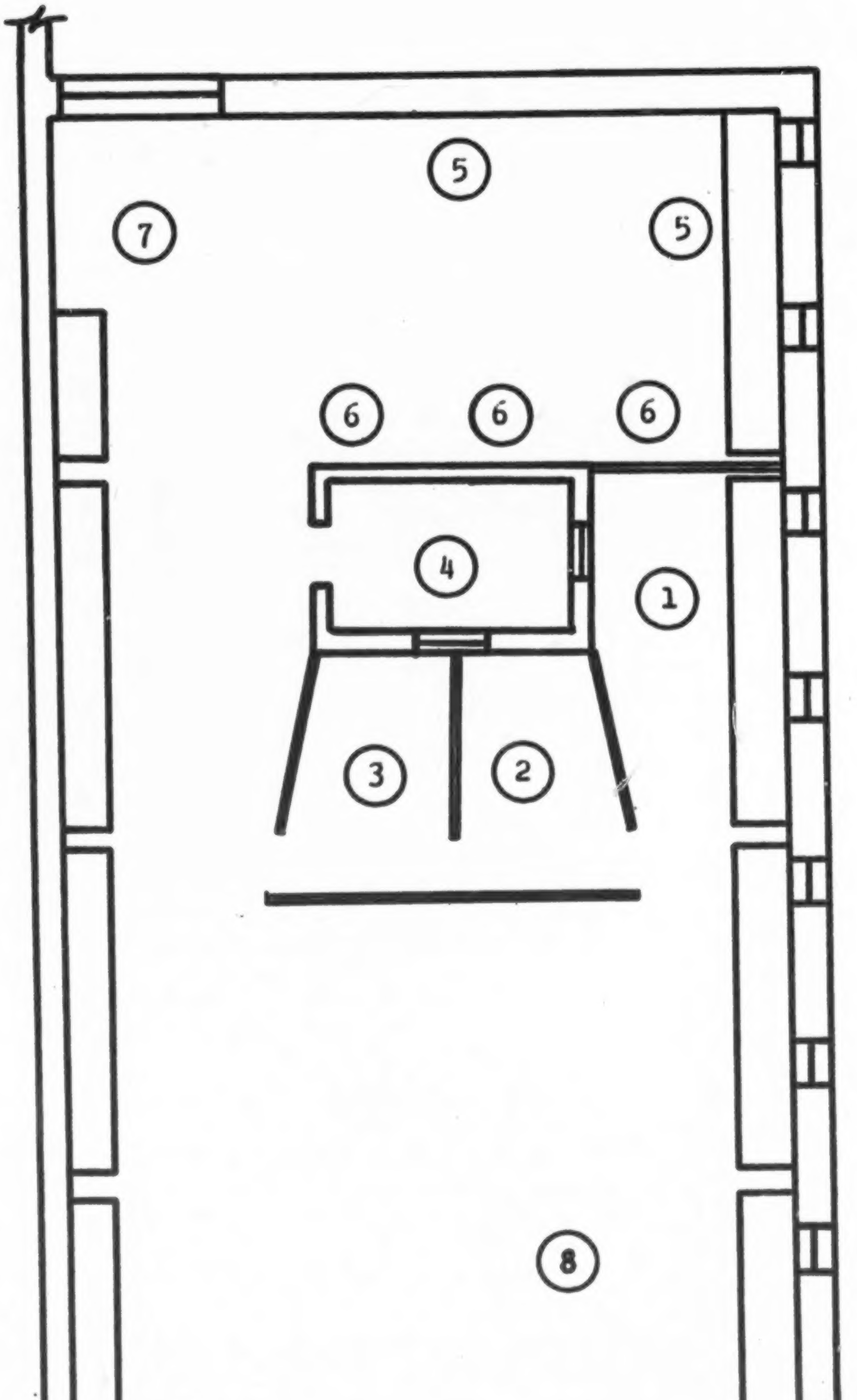
FLOOR PLAN OF THE EXPERIMENTAL WORKSHOP

Legend:

1. Experimental Task I Station (Drilling)
2. Experimental Task II Station (Sanding)
3. Experimental Task III Station (Basket Assembly)
4. Experimental Cubical and Observation Stations
5. Prefabrication Areas
6. Assembly Areas
7. Finishing Areas
8. Materials Storage

Note:

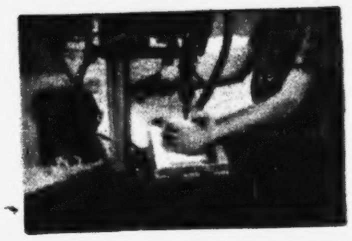
Drawing scale: 1/8" = 1'


Entry

APPENDIX D

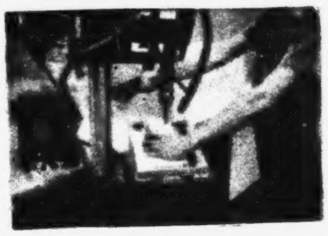
EXPERIMENTAL ENVIRONMENT, TASK, AND SUBJECT RELATIONSHIPS AT POINT OF EMISSION OF CRITICAL TASK OPERANTS

Task I


Operant #15

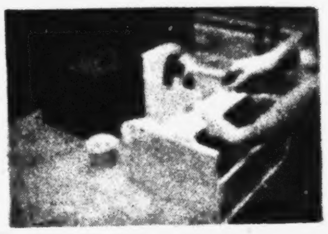
Operant #30

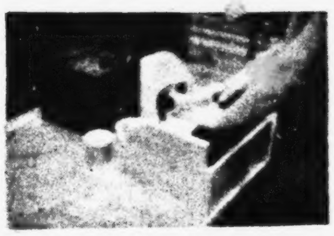
Operant #45

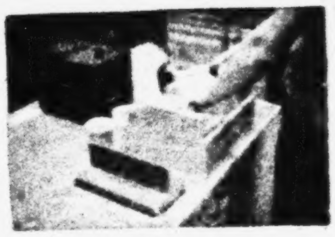

Operant #64

Operant #79

Operant #94


Operant #42

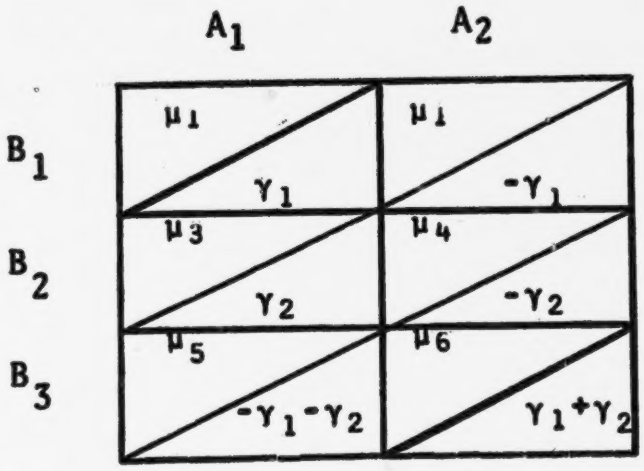

Operant #73


Operant #109

APPENDIX E

STATISTICAL DESIGN EMPLOYED IN THE ANALYSIS OF THE CONTROL AND EXPERIMENTAL GROUP DATA

Design:



	A_1	A_2
B_1	μ_1 γ_1	μ_1 $-\gamma_1$
B_2	μ_3 γ_2	μ_4 $-\gamma_2$
B_3	μ_5 $-\gamma_1-\gamma_2$	μ_6 $\gamma_1+\gamma_2$

Where:

A_1 = Control Group

A_2 = Experimental Group

B_1 = Task I

B_2 = Task II

B_3 = Task III

μ = Group Means

γ = Interactions

APPENDIX F

MATHEMATICAL MODEL EMPLOYED IN THE ANALYSIS OF THE CONTROL AND EXPERIMENTAL GROUP DATA

Regression Model Assuming Interactions:

$$Y_{ij} + \mu_i + \alpha(X_{ij} - \overline{X}) + \beta(Z_{ij} - \overline{Z}) + \text{error}$$

Where: i = group

j = individual within group

Y = dependent (operant measures)

α = first covariable (I.Q.)

β = second covariable (admission age)

With: $\mu_i = M + cU_i + \gamma_1 V_{1i} + \gamma_2 V_{2i} + \gamma_1 I_{1i} + \gamma_2 I_{2i}$

Where: μ_i = group means

M = grand mean

cU_i = column effect

$\gamma_1 V_{1i}$ = trend effect (linear)

$\gamma_2 V_{2i}$ = quadratic effect

$\gamma_1 I_{1i}$ and

$\gamma_2 I_{2i}$ = interactions

And: $U = -1$ if $i = 1, 3, 5$

$U = 1$ if $i = 2, 4, 6$

$V_1 = -1$ if $i = 1, 2$

$V_2 = 0$ if $i = 3, 4$

$V_1 = 1$ if $i = 5, 6$

$V_2 = 1$ if $i = 1, 2, 5, 6$

$V_2 = -2$ if $i = 3, 4$

$I_1 = 1$ if $i = 1, 6$

$I_1 = 1$ if $i = 2, 5$

$I_1 = 0$ if $i = 3, 4$

$I_2 = 1$ if $i = 3, 6$

$I_2 = -1$ if $i = 4, 5$

$I_2 = 0$ if $i = 1, 2$

Tests Employed:

H_1: $c = 0$ (treatment effect allowing for effect of covariables)

H_2: $\gamma_1 = \gamma_2 = 0$ (task effect)

H_3: $\gamma_1 = \gamma_2 = 0$ (interaction effect)

APPENDIX G

SINGLE-MULTIPLE LINEAR REGRESSION ANALYSIS PROGRAM

Introduction

This program uses a least squares procedure to calculate the estimates of the partial regression coefficients b_o, b_1, b_2,......, b_k in the multiple linear model

$$y = b_o + b_1x_1 + b_2x_2 + \ldots\ldots + b_kx_k$$

The maximum number of independent variables, x_k, is ten; that is, $1 \leq k \leq 10$. When k = 1, the program estimates b_o and b_1 in the single linear model

$$y = b_o + b_1x_1$$

The program also computes the partial correlation coefficients, the multiple correlations coefficient, the standard error of the y data, the standard error of the estimate, the significance of the regression (F), and the standard error of the partial regression coefficients. This set of information is most useful in making subsequent tests on the data or the fitted relation.

The output is via the punched cards and is complete with table headings and labels.

Operating Instructions

Program switch 1 controls whether the first or the last of the variables in each observation is to be considered as the dependent variable; with switch 1 off, the first variable in each set of numbers comprising one observation is considered to be the dependent variable; if switch 1 is on, then the last number in each set is considered to be the dependent one. The other program switches are not used.

The data for each study is preceded by two header cards, as follows:

Card 1: The number of independent variables in columns 1-7; the number of data points (number of observations) in columns 8-14.

Card 2: Specification of the format in which data will appear (must be written as a FORMAT statement according to the rules for TAKE II) (UO-0042)

Immediately following the header cards are the data cards in the order and format described by the header card 2.

APPENDIX H

COMPUTER DATA CARD LAYOUT

⇦ Card Column No. ⇨ (Task I - Control)

Card #	1	2	3	4	5	6	7	13	14	21	22	29	30	41	42	49	50	61	62	69	70
1	4	.	3	3	0	7	3	3	9	1	6	-	1	-	1		1		1		0
2	4	.	4	5	4	3	5	2	0	1	3	-	1	-	1		1		1		0
3	4	.	6	3	4	7	3	1	9		4	-	1	-	1		1		1		0
4	4	.	1	4	3	1	3	1	2		3	-	1	-	1		1		1		0
5	4	.	4	8	8	6	4	1	6		5	-	1	-	1		1		1		0
6	4	.	7	1	8	5	0	2	1		2	-	1	-	1		1		1		0
7	4	.	4	8	8	6	4	2	3	1	4	-	1	-	1		1		1		0
8	4	.	6	1	5	1	2	1	9	1	3	-	1	-	1		1		1		0
9	4	.	0	7	7	5	4	2	9	1	1	-	1	-	1		1		1		0
10	4	.	3	6	9	4	5	1	6		4	-	1	-	1		1		1		0
11	3	.	9	5	1	2	4	4	1	1	4	-	1	-	1		1		1		0

⇦ Card Column No. ⇨ (Task I - Experimental)

Card #	1	2	3	4	5	6	7	13	14	21	22	29	30	41	42	49	50	61	62	69	70
12	4	.	7	9	5	7	9	2	9		7		1	-	1		1	-	1		0
13	4	.	7	2	7	3	9	2	5	1	8		1	-	1		1	-	1		0
14	4	.	2	0	4	6	9	1	5		8		1	-	1		1	-	1		0
15	5	.	0	6	8	9	0	2	7	1	4		1	-	1		1	-	1		0
16	4	.	7	7	9	1	2	2	8	1	2		1	-	1		1	-	1		0
17	4	.	6	0	5	1	7	2	0	1	7		1	-	1		1	-	1		0
18	4	.	5	9	5	1	2	3	0	1	0		1	-	1		1	-	1		0
19	4	.	4	1	8	8	4	2	4		1		1	-	1		1	-	1		0
20	4	.	3	4	3	8	0	1	4		2		1	-	1		1	-	1		0
21	3	.	8	0	6	6	6	2	1	1	3		1	-	1		1	-	1		0
22	4	.	5	7	4	7	1	1	5		8		1	-	1		1	-	1		0

⇦ Card Column No. ⇨ (Task II - Control)

Card #	1	2	3	4	5	6	7	13	14	21	22	29	30	41	42	49	50	61	62	69	70
23	7	.	0	1	9	3	0	3	9	1	6	-	1		0	-	2		0		1
24	7	.	4	9	6	1	0	2	0	1	3	-	1		0	-	2		0		1
25	7	.	2	9	3	0	2	1	9		4	-	1		0	-	2		0		1
26	7	.	5	6	0	0	8	1	2		3	-	1		0	-	2		0		1
27	7	.	1	1	0	7	0	1	6		5	-	1		0	-	2		0		1
28	6	.	9	7	5	4	1	2	1		2	-	1		0	-	2		0		1
29	7	.	3	2	3	8	3	2	3	1	4	-	1		0	-	2		0		1
30	7	.	0	0	3	0	6	1	9	1	3	-	1		0	-	2		0		1
31	6	.	6	7	8	3	4	2	6	1	1	-	1		0	-	2		0		1
32	6	.	3	9	1	9	2	1	9		4	-	1		0	-	2		0		1
33	6	.	6	9	9	5	0	4	1	1	4	-	1		0	-	2		0		1

- -

⇦ Card Column No. ⇨ (Task II - Experimental)

Card #	1	2	3	4	5	6	7	13	14	21	22	29	30	41	42	49	50	61	62	69	70
34	7	.	0	5	1	8	6	2	9		7		1		0	-	2		0	-	1
35	6	.	2	5	5	7	5	2	5	1	8		1		0	-	2		0	-	1
36	7	.	1	8	6	9	0	1	5		8		1		0	-	2		0	-	1
37	7	.	6	5	0	6	4	2	7	1	4		1		0	-	2		0	-	1
38	7	.	7	2	1	3	5	2	8	1	2		1		0	-	2		0	-	1
39	7	.	6	9	9	8	4	2	0	1	7		1		0	-	2		0	-	1
40	7	.	1	2	9	3	0	3	0	1	0		1		0	-	2		0	-	1
41	6	.	9	3	5	3	7	2	4		1		1		0	-	2		0	-	1
42	6	.	9	5	0	8	1	1	4		2		1		0	-	2		0	-	1
43	6	.	8	4	5	8	8	2	1	1	3		1		0	-	2		0	-	1
44	7	.	0	3	2	6	2	1	5		8		1		0	-	2		0	-	1

⇦Card Column No.⇨ (Task III - Control)

Card #	1	2	3	4	5	6	7	13	14	21	22	29	30	41	42	49	50	61	62	69	70
45	4	.	8	2	0	2	8	3	9	1	6	-	1		1		1	-	1	-	1
46	3	.	9	3	1	8	3	2	0	1	3	-	1		1		1	-	1	-	1
47	4	.	7	2	7	3	9	1	9		4	-	1		1		1	-	1	-	1
48	3	.	9	1	2	0	2	1	2		3	-	1		1		1	-	1	-	1
49	3	.	8	7	1	2	0	1	6		5	-	1		1		1	-	1	-	1
50	4	.	2	7	6	6	7	2	1		2	-	1		1		1	-	1	-	1
51	3	.	9	8	8	9	8	2	3	1	4	-	1		1		1	-	1	-	1
52	4	.	5	1	0	8	6	1	9	1	3	-	1		1		1	-	1	-	1
53	3	.	7	1	3	5	7	2	9	1	1	-	1		1		1	-	1	-	1
54	3	.	8	2	8	6	4	1	6		4	-	1		1		1	-	1	-	1
55	2	.	9	9	5	7	3	4	1	1	4	-	1		1		1	-	1	-	1

⇦Card Column No.⇨(Task III - Experimental)

Card #	1	2	3	4	5	6	7	13	14	21	22	29	30	41	42	49	50	61	62	69	70
56	4	.	6	7	2	8	3	2	9		7		1		1		1		1		1
57	4	.	6	3	4	7	3	2	5	1	8		1		1		1		1		1
58	4	.	0	4	3	0	5	1	5		8		1		1		1		1		1
59	4	.	5	9	5	1	1	2	7	1	4		1		1		1		1		1
60	4	.	4	9	9	8	1	2	8	1	2		1		1		1		1		1
61	4	.	3	4	3	8	0	2	0	1	7		1		1		1		1		1
62	4	.	7	0	0	4	8	3	0	1	0		1		1		1		1		1
63	4	.	1	2	7	1	3	2	4		1		1		1		1		1		1
64	4	.	3	5	6	7	1	1	4		2		1		1		1		1		1
65	4	.	2	6	2	6	8	2	1	1	3		1		1		1		1		1
66	3	.	9	3	1	8	3	1	5		8		1		1		1		1		1

APPENDIX I

COMPUTER PROGRAM SEQUENCE

Pass I (Main Analysis)

Index Card: 7, 66
Format: (3X, F7.5, 2X, F2.0, 6X, F2.0, 2(6X, F2.0, 10X, F2.0), 6X, F2.0)
Data Cards: 1 through 66

Pass II (Control *vrs.* Experimental; Task I)

Index Card: 3, 22
Format: (3X, F7.5, 2X, F2.0, 6X, F2.0, 6X, F2.0)
Data Cards: 1 through 22

Pass III (Control *vrs.* Experimental; Task II)

Index Card: 3, 22
Format: (3X, F7.5, 2X, F2.0, 6X, F2.0, 6X, F2.0)
Data Cards: 23 through 44

Pass IV (Control *vrs.* Experimental; Task III)

Index Card: 3,22
Format: (3X, F7.5, 2X, F2.0, 6X, F2.0, 6X, F2.0)
Data Cards: 45 through 66

APPENDIX J

INTER-OBSERVER RELIABILITY FOR SANDING OPERANTS

Repeated Observations	Observers	
	#1	#2
1	111	111
2	109	104
3	153	148
4	64	63
5	95	96
6	195	193
7	110	112
8	133	131
9	115	115
10	78	76
11	110	105
12	85	85
13	122	119
14	110	104
15	188	183
16	148	150
17	72	70
18	73	73
19	111	107
20	164	165

ΣX_{1_2} 2346 ΣX_{2_2} 2311

ΣX_1 301142 ΣX_2 292515

$\Sigma X_1 X_2 = 296738$

$\underline{r} = .99$